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BIG RIVER RESERVOIR PROJECT. PAWCATUCK RIVER AND NARRAGANSETT B--ETC(U)
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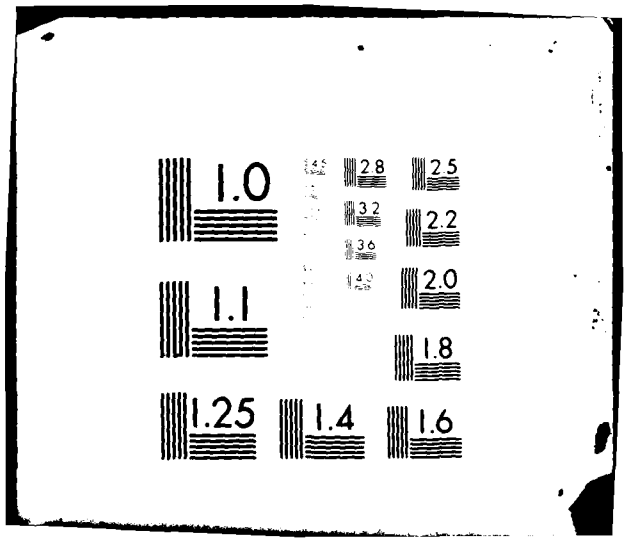
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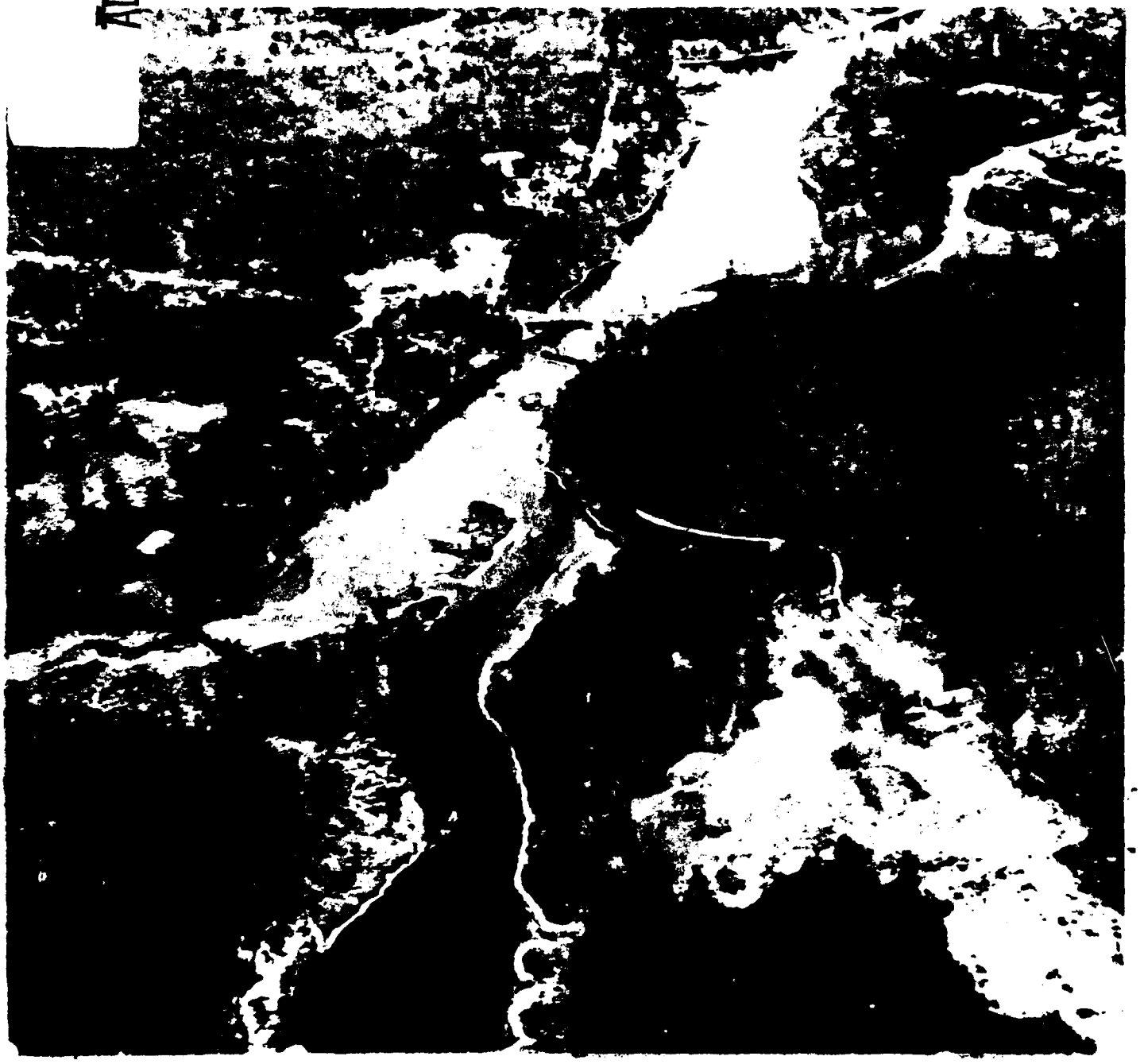
Interim Report

Volume I - Main Report, July 1981

Big River Reservoir Projects



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to evaluate all feasible alternative plans for providing adequate water supplies, protecting flood-prone areas, preventing flood damages and meeting the recreational needs of the Pawcatuck river and Narragansett Bay Drainage Basin area. Three detailed plans were formulated, assessed and compared using economic, engineering, social and environmental criteria.

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Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

INDEX OF VOLUMES

(6)

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

Volume I.

MAIN REPORT

(12) 484

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

(11) July 1961

MAIN REPORT

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EXECUTIVE SUMMARY

In January 1978, the Governor of Rhode Island requested that the Corps of Engineers determine the feasibility of constructing a reservoir at the Big River site to provide additional water supply to the Providence metropolitan area. Flood control studies underway at the time indicated that storage of floodwaters at the Big River site could be a viable solution to the flooding problem evident along the lower Pawtuxet River. This report is an interim report to the overall Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Urban Study, and assesses the feasibility of Big River Reservoir as a multi-purpose facility providing water supply, flood control and recreation.

The State of Rhode Island acquired lands at the Big River site in 1965 with the aim of developing a water supply reservoir. However, funds for design and construction were not forthcoming, eventually leading to the Governor's request to the Corps. This feasibility study has examined various alternatives to meet water supply, flood control and recreation needs in the Big River study area. Of the methods studied to satisfy the water supply needs of the study area, demand modification (water conservation), groundwater and surface water development were determined to be most feasible alternatives. Flood control storage at Big River Reservoir was found to be the most feasible method of flood damage reduction in the Pawtuxet basin. Recreation needs were best met by recreational development at the Big River site, to a maximal level consistent with the water supply purpose of the reservoir.

From the results of the intermediate studies, three detailed plans were formulated, meeting projected water supply and recreation needs throughout the study timeframe and providing flood damage reduction in flood prone areas along the Pawtuxet River. Plan A, the NED Plan, consists of implementation of a demand modification program throughout the study area, development of local groundwater to serve Foster, Glocester, and Bristol County, and development of a multipurpose Big River Reservoir, including water supply and flood control storage and development of recreation facilities. Plan B, the EQ plan, is similar to Plan A and provides all of the same facilities, but also provides additional environmental enhancement features and measures to minimize social disruption at the Big River Reservoir development. Plan C, the recommended plan, is similar to Plan B, but does not include the extra environmental enhancement features. The major difference between Plan C and the others is that Plan C provides a more regional approach to water supply for the study area, including a connector from the Providence system to meet the long term needs of Bristol County, for which groundwater development would be less extensive. Flood damage reduction measures and recreation facilities are the same under all three plans.

Early public involvement efforts were developed and implemented under contract with the University of Rhode Island. These efforts elicited opinions from the general public, elected officials at the State and

community level, and Federal and State agencies concerned with water resources development. Public meetings, workshops, meetings with special interest groups, newsletters and information pamphlets were among the techniques utilized throughout the study to promote information exchange and feedback on public desires and the Corps' plans.

This report recommends that the United States Congress authorize a plan of water resources development for the metropolitan Providence area that includes: (1) a multiple purpose reservoir providing water supply, flood control and recreation at the Big River site; (2) development of local groundwater in certain areas as water supply sources; (3) a water conservation program for the entire metropolitan area. Of this overall water resources plan, the report recommends Federal construction of the $155.5 million Big River dam and reservoir project, excluding those elements which are not within Corps of Engineers implementation authority. Such elements, which include treatment facilities and the seven mile long finished-water aqueduct to the Providence system, would be built by local interests. Total first cost of the Federally implemented portion of the Big River Reservoir project is $71.2 million, of which $37.6 million is the value of State-owned lands on which the project would be built. Federal costs would be $6.6 million under existing legislation or $5.0 million under former President Carter's 1978 Water Policy. Costs of the project allocated to water supply would be reimbursed to the Federal government by the local sponsors over a fifty year period.

The various elements of the plan would be developed in a time-phased manner, with the Big River Reservoir scheduled to become operational in 1995. The plan appears to have public approval, and the Big River project has received the endorsement of the Governor of Rhode Island.

At the present time the State of Rhode Island is preparing to proceed with advanced engineering and design studies on the Big River project with $5.23 million in funding, part of a bond issue approved by Rhode Island voters in November 1980. The present State-funded efforts are expected to coordinate with any Federally authorized actions on the project.

INTRODUCTION

This report summarizes the efforts contained in the Big River Reservoir feasibility study. To familiarize the reader with the aims of the feasibility study and the resources utilized in the study, introductory and background information is provided herein, and in the section following.

STUDY AUTHORITY

The Big River Reservoir feasibility study is authorized under seven Congressional resolutions which were combined under one resolve and adopted by the Committee on Public Works of the United States Senate. These resolves authorized the Pawcatuck River and Narragansett Bay (PNB) study, of which this report is a part. This feasibility study was undertaken in response to a request in January 1978 by the Governor of Rhode Island that the Corps of Engineers determine the feasibility of constructing the Big River Reservoir as a multi-purpose project. The proposed Big River Reservoir site is located in the Pawtuxet River Basin which is included under the PNB authority.

SCOPE OF THE STUDY

The Big River Reservoir feasibility study focused on the water supply, flood damage and recreation problems in the study area. The study evaluated all feasible alternative plans for providing adequate water supplies to the region, protecting flood-prone areas and preventing flood damages, and meeting the recreational needs of the study area. Costs, benefits and environmental impacts of the various alternatives were investigated leading to the selection of a plan that would most effectively meet the identified needs.

Detailed investigations were limited to the communities within the Pawtuxet River Basin and for water supply planning to the legislated service area of the Providence Water Supply Board. Not all areas were investigated to the same level of detail but only where improvements warranted detailed study.

Proposals have been evaluated using economic, engineering, social and environmental criteria. To aid in the evaluation of alternatives, detailed investigations have been made on geotechnical, hydrologic and engineering aspects of the proposed Big River Reservoir. Inventories of aquatic and terrestrial ecosystems, as well as historic and archaeological features of the site, were undertaken to better assess associated environmental and social impacts of the proposed reservoir.

The Big River Reservoir feasibility study is a survey level study, the findings of which will be reported in a feasibility report, the culmination of an approximately three year effort. The findings of this report could lead to implementation of any recommended projects with Congressional and local approval.

The other areas of the PNB study region not addressed by this study are the focus of other studies being conducted by the Corps of Engineers in total response to the authorizing resolutions.

STUDY PARTICIPANTS AND COORDINATION

The U.S. Army Corps of Engineers was given the responsibility for conducting and coordinating the Pawcatuck River and Narragansett Bay Drainage Basins (PNB) study, of which this interim report is a part. The preparation of this report has utilized information developed in other Corps investigations and studies conducted by other agencies.

The studies and investigations for this report were prepared with the cooperation of a large number of agencies. Included in these agencies were the following:

Federal Agencies

U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency

State Agencies

Rhode Island Governor's Office
Rhode Island Water Resources Board
Rhode Island Office of State Planning
Rhode Island Department of Environmental Management
Rhode Island Department of Transportation
Rhode Island Department of Health

Local Interests

Providence Water Supply Board
Bristol County Water Company
Kent County Water Authority
Audubon Society of Rhode Island
Rhode Island League of Women Voters
Ecology Action for Rhode Island

The study effort provided the opportunity for direct participation and coordination by Federal, State and local agencies as well as interested citizens groups. As a means of encouraging full participation by all sectors of the public, several series of formal public workshops, public meetings and informational meetings were held throughout the study area to discuss alternative plans.

Public involvement efforts regarding possible flood damage reduction plans for the Pawtuxet River Basin began in May 1969 with the start of the PNB study. Four public meetings were held at that time to gather infor-

mation about problems and needs. In May 1975, two public meetings were held to present alternative plans and incorporate public desires into the most desirable alternative. At this time the Natick Diversion proposal received public support, although further environmental studies were requested.

In October 1976, a further public meeting was held to prevent the study findings. The recommended plan was now found unacceptable by the public, due to high construction costs and fear of environmental harm to Greenwich Bay. Redirection of the study efforts was accomplished with meetings held between October 1976 and May 1977. The resulting local flood management measures were discussed with State and local interests in March and May 1979, to develop the present alternatives.

A series of three workshop sessions were held in September 1978 to obtain public input on problems, needs and issues surrounding the Big River Reservoir project. A further set of workshops was held in June 1979 to present the preliminary results of plan formulation and to obtain input on detailed water resources plans for the study area. Informal meetings were also conducted during the summer months of 1979 with various interest groups and members of the Project Working Committee, a group set up to facilitate the exchange of information and ideas between the Corps and the general public. Several briefing sessions were held on specific issues surrounding the study, as a further aid in informing the public and coordinating study efforts.

A final public meeting was held in March 1981 to present the results of the draft feasibility report and DEIS and to obtain formal public comments on the draft documents. Comments received at the meeting and during the comment period following release of the draft report were utilized in making a final selection of a plan of action for the study area, and in the formulation of the Division Engineer's recommendation on further Federal involvement. The public participation and coordination structure of the study is shown on Plate 1.

Further information regarding public involvement efforts during the study can be found in Appendix C, "Public Participation," and in "Attachment 1."

STUDIES OF OTHERS

There have been many water resources related studies conducted in the State of Rhode Island in the past 20 years. A complete listing of these reports along with a brief summary of each can be found in the Problem Identification Appendix. A number of these reports have considered the proposed Big River Reservoir as a source for additional water supply to the Providence metropolitan area as well as an aid in flood control. Those reports specifically mentioning the Big River Reservoir are listed below:

1952 C.A. Maguire and Associates recommended several reservoir sites, including Big River and Nooseneck River, as sources of water supply for Providence, in a report to the R.I. Water Resources Commission (now the Water Resources Board).

1957 Metcalf and Eddy, Inc., in a report to the Water Resources Board recommended construction of Big River Reservoir and the Wood River diversion.

1967 In another report to the Water Resources Board, Metcalf and Eddy, Inc. again recommended development of Big River Reservoir and flood skimming from the Flat River Reservoir.

1968 C.A. Maguire and Associates recommended development of Big River and Wood River reservoirs to the Providence Water Supply Board.

1969 The Northeastern United States Water Supply (NEWS) Study by the Corps of Engineers proposed development of Big River Reservoir and flood skimming from the Flat River Reservoir.

1971 A flood control reconnaissance report on the Pawtuxet River Basin by the Corps of Engineers recommended detailed study for floodwater storage at the proposed Big River Reservoir.

1976 The Southeastern New England (SENE) report by the New England River Basins Commission (NERBC) recommended construction of Big River Reservoir.

1979 The PNB "Water Supply Alternatives" by the Corps of Engineers again recommended development of the Big River Reservoir.

1980 The Section 208 water quality management plan for Rhode Island establishes management strategies for the control of point and nonpoint sources of pollution, and includes an analysis of the impact of the proposed Big River Reservoir on water quality and wastewater generation in the Pawtuxet Basin.

This report is an interim report of the PNB urban study which addresses flood control and flood plain management, water supply, coastal restoration and protection and navigation. Drainage basins reported on in the PNB study include the Pawtuxet River, Taunton River, Pawcatuck River, Narragansett Bay Local Drainage and the Providence River Group, comprised of the Blackstone, Woonasquatucket, Moshassuck and Ten Mile River Basins. An interim report is scheduled for release in FY 1981 on the Blackstone River Basin. Investigations of the other basins are being completed this year, with findings and recommendations due to be included in the overall PNB report scheduled for publication in FY 1981.

STUDY PARTICIPANTS AND COORDINATION

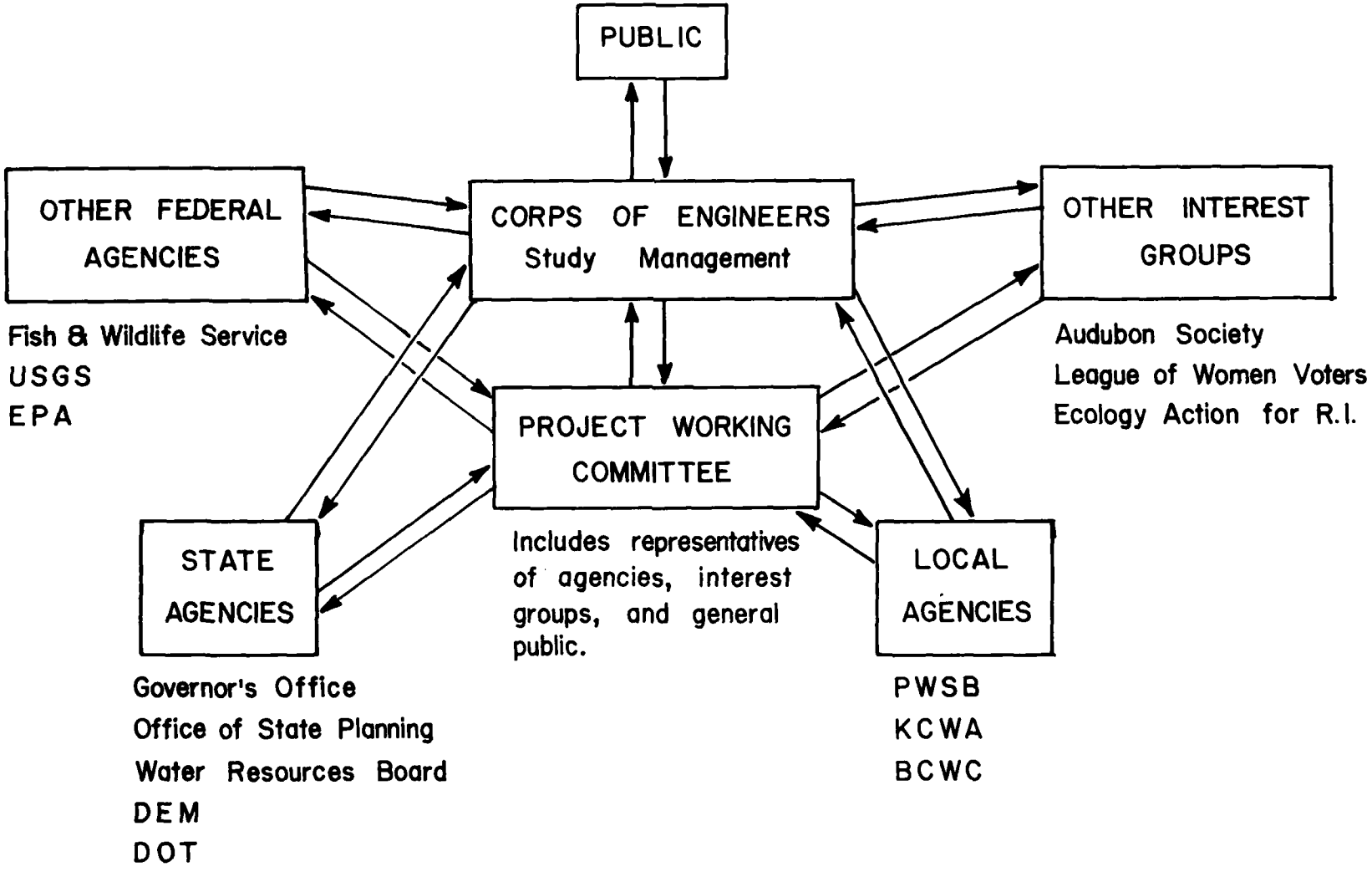


PLATE 1

THE REPORT AND STUDY PROCESS

In the interest of clarity of presentation, this report has been arranged into a main report, including an environmental impact statement, and eleven technical appendices.

The Main Report is the basic document which presents a summary of the overall planning process and study results for the benefit of both general and technical readers. It includes a description of problems and needs, plan formulation procedures and an assessment and evaluation of each plan's social, economic and environmental aspects. It also contains study findings, conclusions and recommendations.

The Environmental Impact Statement (EIS), included in the Main Report, consists of a description of the existing environmental baseline conditions and expected impacts resulting from the final detailed water resources plans. The EIS contains sufficient detail of the selected plan to permit an unbiased assessment of potential environmental impacts and issues by appropriate Federal, State and municipal agencies and the concerned public. All pertinent correspondence and evaluated input generated by review of the draft EIS is assimilated into the final EIS.

The technical appendices present supporting data and specific details of various elements of the study. Also included as an attachment to this report is a report documenting the detailed flood damage reduction investigations for the Pawtuxet River Basin. The report is contained in a total of four volumes as follows:

Volume I	Main Report (including EIS and Section 404 Evaluation)
Volume II	Appendix A - Problem Identification Appendix B - Plan Formulation Appendix C - Public Participation Appendix D - Hydrologic Analysis Appendix E - Water Quality Appendix F - Geotechnical Investigations Appendix G - Design and Cost Estimates
Volume III	Appendix H - Recreation and Natural Resources Section 1 - Recreation Impact Analysis Section 2 - Aquatic Ecosystem Assessment Section 3 - Terrestrial Ecosystem Assessment Section 4 - Fish and Wildlife Management Plan (including U.S. F&WS Report) Appendix I - Social and Cultural Resources Section 1 - Social Resources Section 2 - Cultural Resource Reconnaissance Appendix J - Economics Appendix K - Institutional Analysis
Volume IV	Attachment 1

The study process that culminates in the feasibility report is divided into three stages: Stage 1 - Reconnaissance Study, Stage 2 - Development of Intermediate Alternatives, and Stage 3 - Development of Detailed Plans and Publication of a Feasibility Report.

Each of the three planning stages incorporates four functional planning tasks which become progressively more detailed. The tasks are problem identification, formulation of alternatives, impact assessment and evaluation.

Problem identification entails several procedures. Identifying public concerns, analyzing resource management problems, defining the study area, describing the base conditions, projecting future conditions, and establishing planning objectives are all elements which are addressed to determine the range of water resources problems a study will investigate.

The second planning task, formulation of alternatives, involves developing different resources management plans comprehensive enough to address the planning objectives and to satisfy future water-related requirements.

Impact assessment identifies and measures the types of impacts caused by various alternatives and estimates the incidence of these impacts.

The fourth planning task, evaluation, is undertaken to analyze the impacts. Evaluation criteria such as public acceptability, completeness, effectiveness, efficiency and benefits versus costs are established, and an analysis is performed to determine each alternative's total impact as well as possible trade-offs among alternatives.

The results of these planning tasks are reviewed to determine if another iteration is needed; if not, the next planning stage is entered. The culmination of the three stages of the planning process is a feasibility report to Congress detailing the recommended plan and asking for authorization for Corps of Engineers implementation, if applicable.

PROBLEM IDENTIFICATION

In this section, background information about existing conditions is presented along with a scenario of conditions expected to occur without any Federal action. This information is analyzed to identify problems, needs and opportunities for the study area, from which national objectives can be set. Planning objectives and constraints then follow from the problems, conditions, and goals identified.

A more detailed description of the information in this section is given in Appendix A, "Problem Identification."

NATIONAL OBJECTIVES

National objectives for water resources planning have been defined in tbe Principles and Standards as achievement of National Economic Development (NED) and Environmental Quality (EQ). NED is to be achieved by increasing the value of the nation's output of goods and services and by increasing the national economic efficiency. EQ is to be achieved by the management, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The NED objectives can be achieved by various project purposes in the study area. Flood control measures can improve the area economy by reducing flood damages and the resulting costs to businesses in the area's flood plains. Solving water supply problems allows residential, commercial and industrial growth in the study area to continue as projected. Water using industries will not be forced to relocate, and new residential and commercial developments will not be restricted by lack of water. Achievement of these projections can lead to increased growth in the work force and per capita income of the area.

The EQ objective can be achieved by the same project purposes, if properly applied. Flood control measures that include or allow preservation of ecologically valuable wetland areas could be adopted. Watershed management measures can increase ecological diversity and productivity of fish and wildlife in the area surrounding surface water development, as well as improving water quality in the impoundment. Recreational development at surface water sites can achieve both EQ and NED aims by increasing or preserving the aesthetic and cultural resources, and by providing recreational opportunities allowing relaxation and increasing worker productivity.

EXISTING CONDITIONS

Physical Conditions

Study Area. The Big River Reservoir study area comprises 469.1 square miles in north central Rhode Island. It is bounded on the west by Connecticut, on the north by Burrillville, North Smithfield, and Lincoln, and on the south by Exeter and North Kingatown. The study area covers almost the entire Pawtuxet River Basin as well as part of the Providence River Group and the Narragansett Bay Local Drainage area.

There are 17 communities within the study area. Providence, North Providence, Cranston, Johnston, East Providence, Smithfield, Warwick, West Warwick, and Coventry receive water from the Providence Water Supply Board system's source, Scituate Reservoir. Foster, Glocester, Scituate, Bristol, Barrington, and Warren do not currently receive their water from Scituate Reservoir but are within the legally mandated service area of the Providence Water Supply Board. These communities are expected to turn to the Providence system in the future for supply augmentation. The two remaining towns, East Greenwich and West Greenwich, are included because of the proposed site's location in or near them and because they are logical recipients for any surplus water from Big River Reservoir.

Providence is the largest city in the study area, more than half of which is undeveloped and forested. The study area is shown on Plate 2.

Climate. The usually harsh extremes of New England weather are tempered in the study area by the moderating effects of Narragansett Bay. The area has a moderately cool and humid climate with an average annual temperature of 50 degrees Fahrenheit throughout the year. Monthly average temperatures range from a high of 73° F in July to a low of 29° F in January. Average precipitation is about 48 inches per year in the vicinity of the Big River Reservoir site. The precipitation is fairly uniformly distributed throughout the year with some occurring during the winter as snowfall.

Floods. Flooding can occur in the Pawtuxet River basin at any time of the year as a result of intense rainfall or in the winter or spring due to rainfall combined with snowmelt. Flood damage potential is concentrated along the lower mainstem areas of the Pawtuxet River where development is most dense. Flood damage surveys have shown that heaviest flood losses would occur in Warwick, Cranston and West Warwick. Some of the most severe floods that have occurred in the last century were in November 1927, March 1936, July 1938, September 1938, August 1954, March 1968 and January 1979.

Droughts. When rainfall is below average for a period of time, the area experiences what is referred to as drought conditions. A drought is defined as a prolonged period of precipitation deficiency which seriously affects both river flows and ground water supplies. The 1961-1967 drought in southeastern New England was one of the greatest ever experienced, the last comparable drought to it was in 1914-1916. The 1960's drought is considered to have a probability of around 1 to 2 percent of occurring in any year.

Detailed hydrological information is contained in Appendix D, "Hydrologic Analysis," and in "Attachment 1," which presents specific information on flood hazard areas in the Pawtuxet River basin.

Topography. The land surface of the study area is about 60 percent forested with the cleared lands in various types of agricultural, residential, commercial and industrial development.

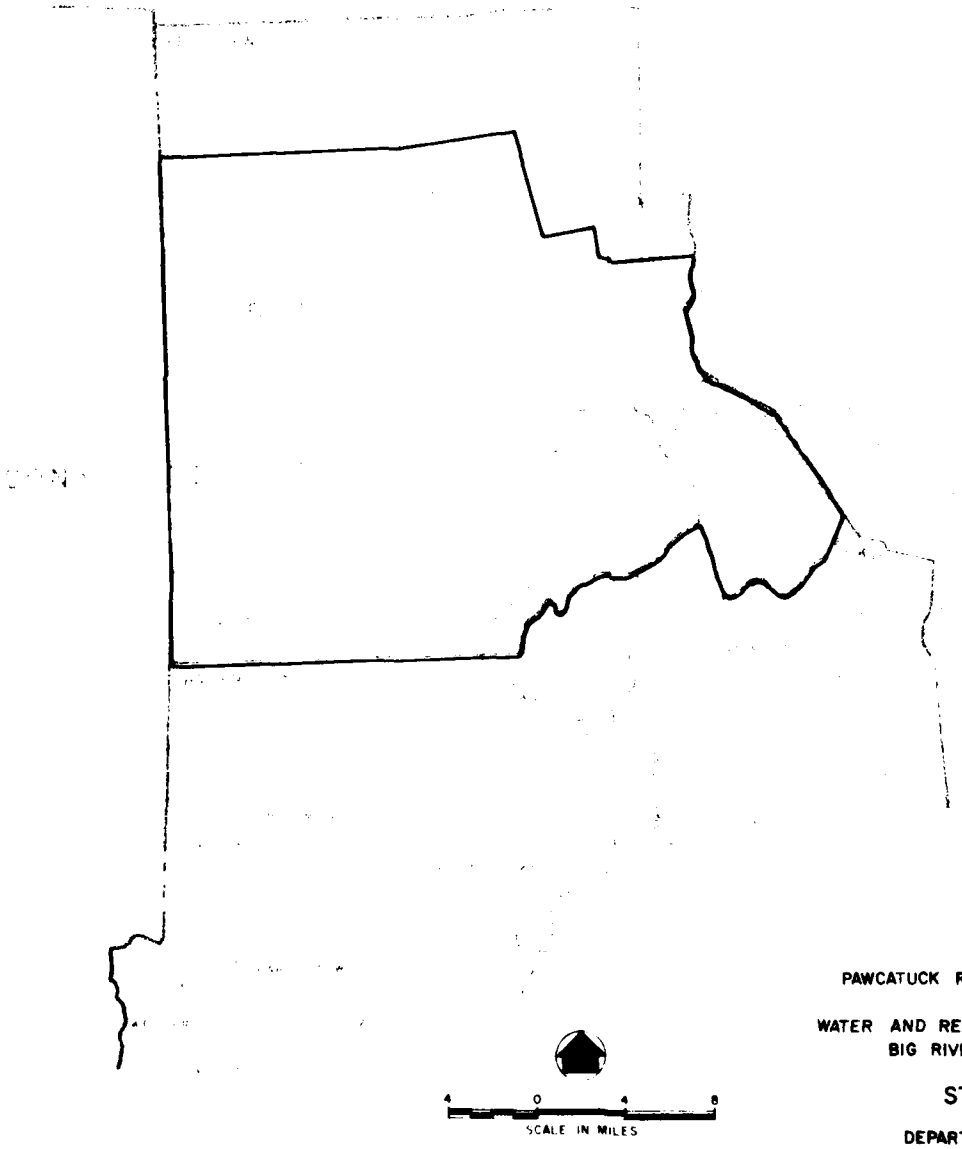
LEGEND

Community Boundary

County Boundary

State Line

Study Limits



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SCALE IN MILES

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

STUDY AREA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 2

The topography has been modified by glacial forces which eroded hills and filled in valleys. The highest point in the Pawtuxet River Basin (and in Rhode Island) is Jermoth Hill, with an elevation of 812 feet above mean sea level, on the basin divide in Foster.

In the western sections of the study area there are low to moderate size hills with a generally decreasing relief to the east.

Geology. In the Pawtuxet River Basin, Scituate Granite Gneiss is the most prevalent bedrock type. There are also sedimentary and metamorphic formations present consisting of sandstones, slates, conglomerates, graywacke, schists and gneiss. The unconsolidated overlaying deposits are predominantly of glacial origin. Post-glacial deposits occur as alluvium on riverbanks and flood plains and as swamp deposits of silts, fine sands and muck. Till deposits of varying thicknesses cover much of the hillside bedrock. Further details are contained Appendix F, "Geotechnical Investigations."

Seismic Activity. Most of the study area is classified as an area of minor damage potential. The northernmost section may undergo moderate damage. The potential for earthquakes has been evaluated and appropriate factors will be applied to any structural designs. For further information see Appendix F, "Geotechnical Investigations."

Natural Resources

Air. Based on R.I. DEM 1979 air quality sampling data, most of the Big River Reservoir study area, except Providence, is able to meet current State and Federal ambient air quality standards. Over the last few years there has been a general improvement in air quality in the area. Providence, however, has for several days each year recorded levels of carbon monoxide and total suspended particulates in excess of those allowable under State and Federal standards. During the summer months, some rural as well as urban sections of the study area have experienced temporary air quality problems, including ozone levels in excess of standards.

Soils. The principal soil type found in the study area is Glocester stony fine sandy loam. There are, however, many other soil types represented in the area. Alluvial soils are found along many streams, Whitman stony loam in wetlands and Hinckley loamy sand is frequently associated with kames. Merrimack fine sandy loam is found in the lowlands of Cranston and Warwick and many low hills are blanketed with Narragansett stony fine sandy loam.

Vegetation. Upland hardwood forests in the study area are characterized by an overstory of mostly oak with scattered pine. Softwood forests are dominated by white and pitch pine. The understory and groundcover consist of various blueberry, beech, laurel, wintergreen and scrub oak.

Wetland types found in the study area include wooded and shrub swamps, deep and shallow marshes, and bogs. Species found there include maple,

cedar, pine, buttonbush, sweet gale, leatherleaf and emergent and floating-leaved herbacious plants.

Fish and Wildlife. All of the alternative reservoir sites in the study area have been identified as inhabited by a similar proportional distribution of wildlife species. Actual population size is dependent on the acreage of the habitats within the sites. Among the species indigenous to the study area are a variety of game birds and animals, waterfowl, song birds, shore and wading birds, fur bearing animals, raptors and rodents.

The numerous streams, ponds and lakes in the study area are well known for the excellent fishing they support. The larger streams include Big River, Nooseneck River and the Congdon River, and support both cold-water and warm-water species. Larger streams are stocked annually with trout, and warm-water species are self-sustaining and not intensively managed. Flat River Reservoir supports a warm water fishery, including largemouth bass, pickerel, bluegill and bullhead.

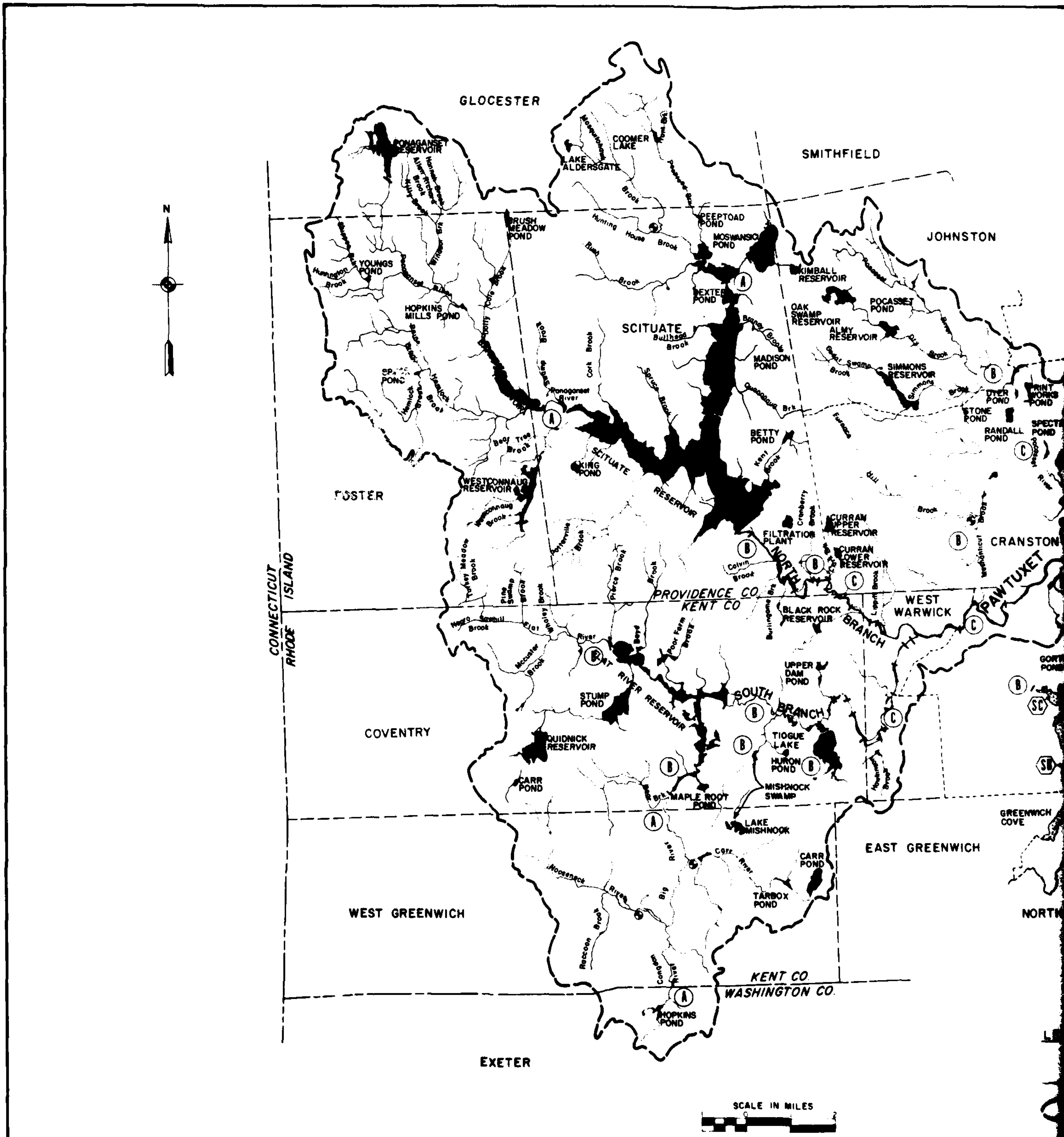
A detailed look at various aspects of fish and wildlife in the Big River Reservoir study area can be found in Appendix H, "Recreation and Natural Resources."

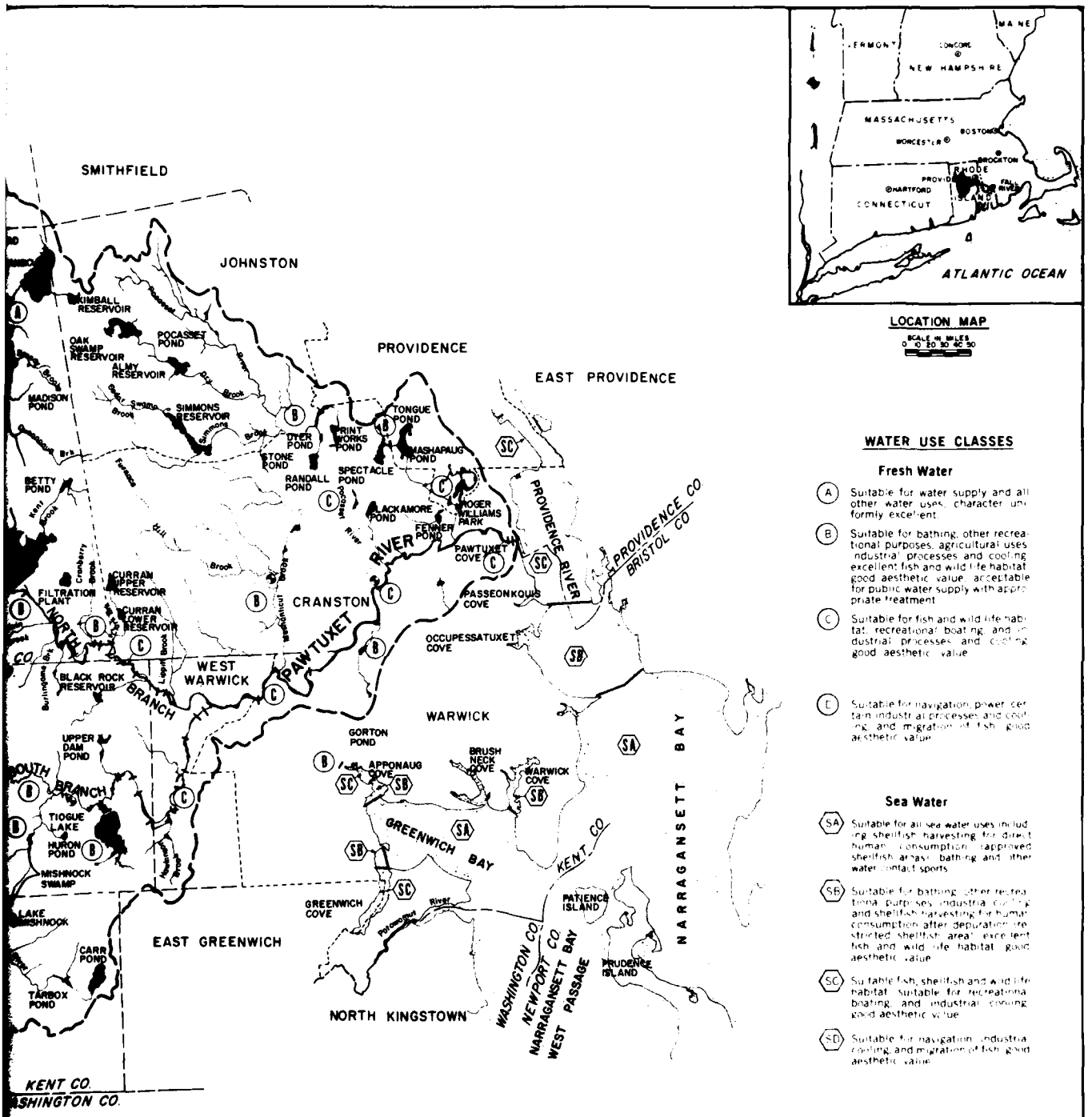
Surface Water. Investigations for flood control and recreation focus on the Pawtuxet River Basin, while the water supply study area includes small portions of several other drainage basins. The Pawtuxet basin is the major watershed in the water supply study area, with a drainage area of 230 square miles. Thus the Pawtuxet River Basin, shown on Plate 3, is the focus of this discussion.

Drainage in the Pawtuxet Basin is generally west to east, and the region has a variable hydrologic character, with hilly topography and numerous small lakes and ponds, plus two larger reservoirs. Drainage is facilitated by many smaller streams and the major stream in the region, the Pawtuxet River. The mainstem flows in a generally northeasterly direction for approximately 11 miles to its mouth at the head of Pawtuxet Cove, with an average slope of about 4.1 feet per mile. The mainstem of the river is formed by the junction of its two principal tributaries, the North and South Branches, in the town of West Warwick. This portion of the river is flat, and highly urbanized along its shores.

The North Branch of the Pawtuxet River has a drainage area of 106 square miles and originates at Scituate Reservoir, the major water supply source for the region with a safe yield of 72 mgd. Below Scituate Reservoir the river flows for 6.8 miles in a generally southeasterly direction, falling fairly steeply (average 21.6 feet per mile) before joining the mainstem.

The South Branch of the Pawtuxet River, with a drainage area of 73 square miles, originates at Flat River Reservoir (Johnson's Pond). This impoundment was constructed downstream of the confluence of the Flat and Big Rivers, and is primarily used for recreational and industrial flow augmentation purposes. The headwaters of the Flat River originate at the


GLOCESTER
SMITHFIELD
JOHNSTON
SCITUATE
FOSTER
CRANSTON
WEST WARWICK
COVENTRY
EAST GREENWICH
WEST GREENWICH
EXETER
PROVIDENCE CO.
KENT CO.
WASHINGTON CO.
CONNECTICUT
RHODE ISLAND
PONAGANSET RESERVOIR
COOMER LAKE
LAKE ALDERSGATE
BRUSH MEADOW POND
PEEPTOAD POND
MOSWANSICUT POND
KIMBALL RESERVOIR
YOUNGS POND
HOPKINS MILLS POND
DEXTER POND
OAK SWAMP RESERVOIR
POCASSET POND
ALMY RESERVOIR
MADISON POND
SIMMONS RESERVOIR
DYER POND
PRINT WORKS POND
STONE POND
RANDALL POND
BETTY POND
KING POND
SCITUATE RESERVOIR
WESTCONNAUG RESERVOIR
FILTRATION PLANT
CURRAN UPPER RESERVOIR
CURRAN LOWER RESERVOIR
BLACK ROCK RESERVOIR
NORTH BRANCH
PAWTUXET
UPPER DAM POND
STUMP POND
FLAT RIVER RESERVOIR
SOUTH BRANCH
QUIDNICK RESERVOIR
TIOGUE LAKE
HURON POND
CARR POND
MAPLE ROOT POND
MISHNOCK SWAMP
LAKE MISHNOCK
TARBOX POND
HOPKINS POND
GREENWICH COVE
Ponaganset River
Hunting House Brook
Bullhead Brook
Cork Brook
Beef Tree Brook
Westconnaug Brook
Turkey Meadow Brook
Pine Swamp Brook
Colvin Brook
Pierce Brook
Roof Farm Brook
Mccuster Brook
Flat River
Noosenec River
Big River
Carr River
Raccoon Brook
Congdon River
N
SCALE IN MILES
0
2



LOCATION MAP

SCALE IN MILES 0 10 20 30 40 50

WATER USE CLASSES

Fresh Water

(A) Suitable for water supply and all other water uses, character uniformly excellent.

(B) Suitable for bathing, other recreational purposes, agricultural uses, industrial processes and cooling, excellent fish and wild life habitat, good aesthetic value, acceptable for public water supply with appropriate treatment.

(C) Suitable for fish and wild life habitat, recreational boating, and industrial processes and cooling, good aesthetic value.

(D) Suitable for navigation, power, certain industrial processes and cooling, and migration of fish, good aesthetic value.

Sea Water

(SA) Suitable for all sea water uses including shellfish harvesting for direct human consumption, approved shellfish areas, bathing and other water contact sports.

(SB) Suitable for bathing, other recreational purposes, industrial cooling and shellfish harvesting for human consumption after depuration, restricted shellfish areas, excellent fish and wild life habitat, good aesthetic value.

(SC) Suitable fish, shellfish and wild life habitat, suitable for recreational boating, and industrial cooling, good aesthetic value.

(SD) Suitable for navigation, industrial cooling, and migration of fish, good aesthetic value.

LEGEND

- Stream Gaging Station
- Existing Dams of Major Significance
- Watershed Limit
- Limits of Water Quality Classification

SCALE IN MILES 0 1 2

PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS
ER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER BASIN

DEPARTMENT OF THE ARMY
NGLAND DIVISION-CORPS OF ENGINEER
WALTHAM, MASS.

PLATE 3

1 2

head of Turkey Meadow Brook in the town of Foster, while principal tributaries of the Big River are the Nooseneck, Congdon, and Carr Rivers in the towns of West Greenwich and Exeter. Below Flat River Reservoir the South Branch flows generally eastward and then northeasterly for 9.0 miles, falling about 21.9 feet per mile, and joins the North Branch and mainstem in West Warwick.

For more information on the Pawtuxet River Basin see Appendix D, "Hydrologic Analysis," and "Attachment 1."

Water Quality. Existing water quality in the study area ranges from Class A (suitable for domestic water quality) at Scituate Reservoir and the Big River, Class B (suitable for domestic water supply with appropriate treatment and for swimming) at Flat River Reservoir and the upper reaches of the North and South Branches, to Class E (nuisance conditions) near the mouth of Pawtuxet Cove. Throughout most of the mainstem, Class C (suitable for fish and wildlife habitat) conditions prevail.

Both point and non-point sources of pollution affect water quality in the Pawtuxet River Basin. Major non-point sources are stormwater runoff from urbanized lower basin areas and leachate from landfill. The major point sources are the municipal wastewater treatment plant discharges and industrial effluents in the lower basin. Water quality for the Pawtuxet River watershed is shown on Plate 3.

Water quality at Scituate Reservoir has generally improved over its lifetime, and now is very good, with low levels of nutrients and metals levels either below detectable levels or EPA recommended limits.

The waters of Big River, Carr River, Nooseneck River and their tributaries, although rated Class A, do not fully meet Class A criteria due to levels of several contaminates in excess of acceptable standards.

The waters of the Wood River are of high quality and fully meet Rhode Island Class A criteria. Bucks Horn Brook and the Moosup River are of generally high quality but do not fully meet the Rhode Island Class A criteria because of high levels of coliform bacteria. Flat River Reservoir has generally good quality water which meets the Class B requirements except for low dissolved oxygen levels.

For more detailed information on water quality in the study area see Appendix E, "Water Quality," and "Attachment 1."

Ground water. Ten major water supply agencies within the State of Rhode Island rely solely on ground water resources while another four agencies utilize systems which combine both ground water and surface water sources of supply. The most significant ground water supplies in the State as well as in the study area are those of the Kent County Water Authority which serves the communities of East Greenwich and West Greenwich as well as parts of Coventry, Scituate and West Warwick.

In 1975 the estimated withdrawal of ground water by municipal systems in the State of Rhode Island amounted to about 24.0 million gallons per day (mgd). Another estimated 13.0 mgd was withdrawn for private residential usage and industrial needs. Within the study area, the two municipal water supply systems utilizing ground water resources - Kent County Water Authority and Bristol County Water Company - supplied about 7.0 mgd from ground water wells in 1975. Estimates of private residential and industrial usage from ground water sources amounted to an additional 7.0 mgd in 1975.

Ground water aquifers with the greatest potential for development of municipal water supply sources have been identified by both the USGS and the State of Rhode Island Water Resources Board in various communities within the study area. However, potential additional ground water development within the study area is limited by high natural concentrations of iron and manganese in some areas, and pollution due to urbanization in others. Although large areal deposits of outwash materials exist in Providence, Cranston, Warwick, West Warwick and Coventry, their development as municipal supply sources is hampered by the high degree of urbanization. Wellfield development by Kent County Water Authority in the area of the South Branch Pawtuxet River and in the Hunt River Basin in East Greenwich accounts for the largest existing public supply sources within the study area. Ground water resources in the Providence-Warwick region supply primarily industrial users due to poor water quality. Other existing ground water supply sources within the study area are used by publicly operated water systems and to meet the demands of private domestic and industrial users.

Water Supply. Three major water supply agencies are located within the study area. The Providence Water Supply Board serves Providence, Cranston, Johnston, North Providence, East Providence, Smithfield and Warwick directly, and also supplies water to the Kent County Water Authority for distribution to its service area. Scituate Reservoir supplies the Providence system with a safe yield of 77.0 mgd, according to studies undertaken by the Corps as a art of this feasibility report, and a maximum day capacity of 144.0 mgd. In 1975 the average daily demand of the system was 62.4 mgd and the maximum day demand was 106.0 mgd.

The Kent County Water Authority serves Coventry, East Greenwich, West Greenwich, West Warwick, and Scituate. Ground water supplies for this system have a safe yield and maximum day capacity of 10.9 mgd. Average daily demand for the system was 6.0 mgd in 1975, with a maximum day demand of 12.4 mgd.

The Bristol County Water Company serves Bristol, Barrington and Warren with surface and ground water supplies. System safe yield is reported at 3.2 mgd with a maximum day capacity of 4.7 mgd. In 1975 demands were reported at 3.4 mgd on the average day and 5.8 mgd for the maximum day.

Commercially Valuable Mineral Resources. Sand and gravel resources within the Big River Reservoir site total over thirty million cubic yards, the largest single mineral deposit within the region. Three private con-

tractors are currently removing one million cubic yards under an agreement with the State, and it is expected that approximately seven million more cubic yards could be removed over the next 10 years, reducing the total unmined sand and gravel deposits possibly affected by any reservoir development at Big River to twenty million cubic yards. Other active sand and gravel quarries in the study area are located in Coventry, West Greenwich, West Warwick, Warwick, Johnston, and Cranston. The largest producer of crushed stone in the State is also located in Cranston, and other crushed stone producers in the study area are in Johnston, Warwick and West Warwick.

Social and Economic Resources

Population. Based on 1975 data the population of the Big River Reservoir study area is 575,000 people. With a land area of 469.1 square miles the population density is 1,235 persons per square mile, making the combined 17 towns of the study area among the most densely populated areas in the country. These 17 communities make up only 45 percent of the total land area of the State of Rhode Island but are inhabited by 60.5 percent of the total State population.

The study area's rate of population increase has been less subject to fluctuation than that of the State as a whole. Although the rate of growth has slowed on both levels, the period of time for which the downturn has occurred is too short to establish a definitive long term trend. In addition, the circumstances surrounding the recent downturn are somewhat unusual in that around 26,000 military personnel were transferred away from the State when three military installations were closed during the early 1970's.

Although total population in the study area increased from 1960 to 1975 by about 54,100 people, for the city of Providence a decrease of about 39,400 people was noted. Providence is the most densely populated community in the study area, at about 9,300 persons per square mile, and the decreases in Providence's population may be due to both out-migration to surrounding towns and to the effects of urban renewal programs on the inner city during the 1970's.

Employment. Employment data for the study area, taken from the 1970 U.S. Census, indicates that 34.6 percent of the working population is employed in manufacturing, 24.3 percent in services, and 18.6 percent in wholesale and retail trade. A further breakdown of the employment mix is shown in Table 1.

TABLE 1

PERCENTAGE EMPLOYMENT MIX

Category	Study Area	State
Manufacturing	34.6	36.6
Trade	18.6	16.4
Service	24.3	25.4
Government	6.2	5.9
Finance, Insurance, Real Estate	5.0	4.4
Transportation, Communications, Utilities	5.0	4.7
Construction	5.5	5.3
Mining, Agriculture	0.6	0.8
Others	0.2	0.5

SOURCE: Compiled from 1970 U.S. Census Data

The major products manufactured within the State and the study area, based on the size of the work forces involved in their production, are jewelry and silverware, textiles, electrical and non-electrical machinery, fabricated metals, and rubber and plastics.

The occupational structure of the labor force in the study area is assumed to be very similar to that of the State, due to the large segment of the State's working population which resides in the study area. U.S. Census data for the State indicates operatives, except transport, to be the largest occupational category totaling 20.4 percent of the 372,304 employed persons; followed by clerical and kindred workers, 17.6 percent; craftsmen and foremen, 14.7 percent; professional and technical, 13.8 percent; service workers, 11.4 percent; managers and administrators, 7.2 percent; sales workers, 6.6 percent; and all others 8.3 percent.

The average unemployment rate for the study area, taken from the Rhode Island Department of Employment Security, is 6.3 percent, lower than that of the State which averages around 8.8 percent.

The median family income for the study area has increased from $5,702 in 1959 to $10,136 in 1969, or approximately 77.8 percent. The median family income for the State increased from $5,589 in 1959 to $9,736 in 1969, or 74.2 percent, which indicates that the study area enjoys a slightly higher median family income than does the State as a whole.

Land Use. The 469.1 square miles of the Big River Reservoir study area consist primarily of forest and open land. A 1970 study determined forest and open land to be 70.2 percent of the total study area, with residential land being the second largest category, 16.6 percent of the land area. Other land use categories comprise a much smaller percentage of the land area as shown on Table 2.

The higher density residential and major industrial areas are located in the eastern part of the study area, while the large forested areas and

open areas are located in the western portion, closer to the Connecticut border. Northern and southern portions of the study area support a diversity of land uses.

During the mid-1960's the State of Rhode Island acquired approximately 8,300 acres of land located in Coventry, West Greenwich and Exeter for the site of the planned Big River water supply reservoir. The site is heavily forested, with numerous wetlands, and open land which includes several surface mining areas. It has remained essentially unchanged since being purchased by the State, and is presently managed for recreation by the Rhode Island Department of Environmental Management.

For a detailed presentation of land use within the Pawtuxet River Basin, see "Attachment 1."

TABLE 2

1970 DISTRIBUTION OF LAND USE IN THE BIG RIVER RESERVOIR STUDY AREA

Category	Percentage of Total
Residential	16.6
Commerical	1.9
Industrial	2.2
Government/Institutional	0.9
Airports	0.3
Recreation	1.0
Conservation	6.9
Forest and Open Land	70.2

Source: Remote Sensing Land Use and Vegetative Cover in Rhode Island, 1974. State Land Use Policies and Plan, 1975.

Transportation. The study area contains a well developed highway system, including Interstate Route 95, a principal connector between New York, Providence, and Boston. Other major highways in the study are I-195, I-295 and U.S. Route 6.

Interstate bus service is provided from a main terminal in Providence to points in Massachusetts, Connecticut and New York by Greyhound and Bonanza bus lines. Intrastate service is provided by several carriers, including the Rhode Island Public Transit Authority, ABC, Pawtuxet Valley and Bonanza bus lines.

Passenger and freight rail service is provided by Conrail (and its passenger subsidary, Amtrak) plus a number of small freight carriers including the Providence and Worcester, Moshassuck Valley, Narragansett Pier, Seaview, and Warwick rail companies.

T.F. Greene Airport in Warwick, with proximity to Providence and direct access from I-95, is the major freight and passenger air terminal

facility in Rhode Island. There are also five other State airports in Rhode Island that provide private plane and charter facilities.

The Port of Providence, which has a 40-foot deep main channel and 27 public and private docks, serves most of the commercial waterborne traffic in the area. There are also cargo facilities accessible to the study area at recently phased out Navy bases in Portsmouth, Middletown and North Kingstown.

Recreation. Five major recreational areas are in or adjacent to the study area. Beach Pond State Park and Arcadia State Park are adjacent to the study area. Colt State Park and two State management areas, Durfee Hill and Wickaboxet, are contained in the study area, as well as the site of the proposed Big River Reservoir. These State-owned lands, totaling approximately 30,000 acres, support a wide variety of recreational activities, including boating, camping, fishing, golfing, hunting, picnicking, swimming and hiking.

Detailed information on recreation resources within the study area is contained in Appendix H, "Recreation and Natural Resources."

Institutional Arrangements. A number of regional water supply agencies, as well as several local systems for individual towns, provide water to the study area. Various other local, State, and Federal agencies have powers related to water supply management.

Within the study area, the two regional agencies supplying water at present are the Providence Water Supply Board, and the Kent County Water Authority. These agencies have the full capability for development and sale of water on the retail and wholesale level.

Local systems provide water for other parts of the study area. Bristol County Water Company is a private company which provides water for Bristol, Barrington, and Warren. Individual private wells provide water to meet the needs of Foster and Scituate, and also supply much of Glocester's needs.

State and Federal agencies regulate the water suppliers, and provide services and investigations involving related aspects of water resources development and water supply management, such as protection of water quality, land use planning, flood control, and fish and wildlife management. Among these agencies are the Rhode Island Department of Environmental Management, and Public Utilities Commission. Federal agencies involved in water resources include the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Soil Conservation Service, Water Resources Council, and several other agencies with peripheral involvement in aspects of water supply or water resources.

For a detailed description of present and alternative future institutional arrangements for the study area, see Appendix K, "Institutional Analysis."

Cultural and Historic Resources. Before the advent of European settlers, the region now known as Rhode Island was inhabited by several different native American groups of Algonquin stock. Archaeological evidence of these early residents still exists today at several locations within the Big River area.

European settlement of the State began in the early 1600's when Roger Williams and his followers fled from neighboring Massachusetts Bay Colony in the wake of religious persecution. The early settlers generally lived on widely scattered farms with the occasional village necessary to provide local services and a few manufactured goods.

During the 1800's numerous small water-powered mills were established along the rivers and streams in the Big River area. Over the years the economy of the area declined, as the mills failed and the farms and villages were abandoned. The ruined remnants of the mill dams and buildings can be found along the now forested banks of the rivers. There are also many abandoned farms and small family graveyards spread across the landscape.

A detailed inventory of the cultural and historic resources of the study area is contained in Appendix I, "Social and Cultural Resources."

WITHOUT CONDITION PROFILE

The without condition profile, which describes conditions which will occur if no Federal action is taken, is based on the projection of the most probable future condition for the study area, which is chosen from among the possible alternative futures studied.

In order to develop plans that would be responsive to immediate, short and long-term needs of the study area, and also to statewide planning goals, the without condition was developed using available planning data and information from Federal, State and local agencies.

Projected population growth is one of the more important elements in developing a most probable future condition, and in this case several alternative scenarios were developed by various agencies. These alternative growth projections were analyzed to determine the most probable and the most compatible with other factors associated with the without condition profile including land use and economic projections.

The Rhode Island Statewide Planning Program developed population projections for the State Land Use Policies and Plan, January 1975, which showed estimates of the population that could be accommodated by 1990 land use projections. In April of 1975, updated population projections were published by the Statewide Planning Program developed primarily to assess the impact of the closings of naval installations in Rhode Island during the early 1970's. The projections showed a gradual reduction in statewide growth over the 1970-2040 time period.

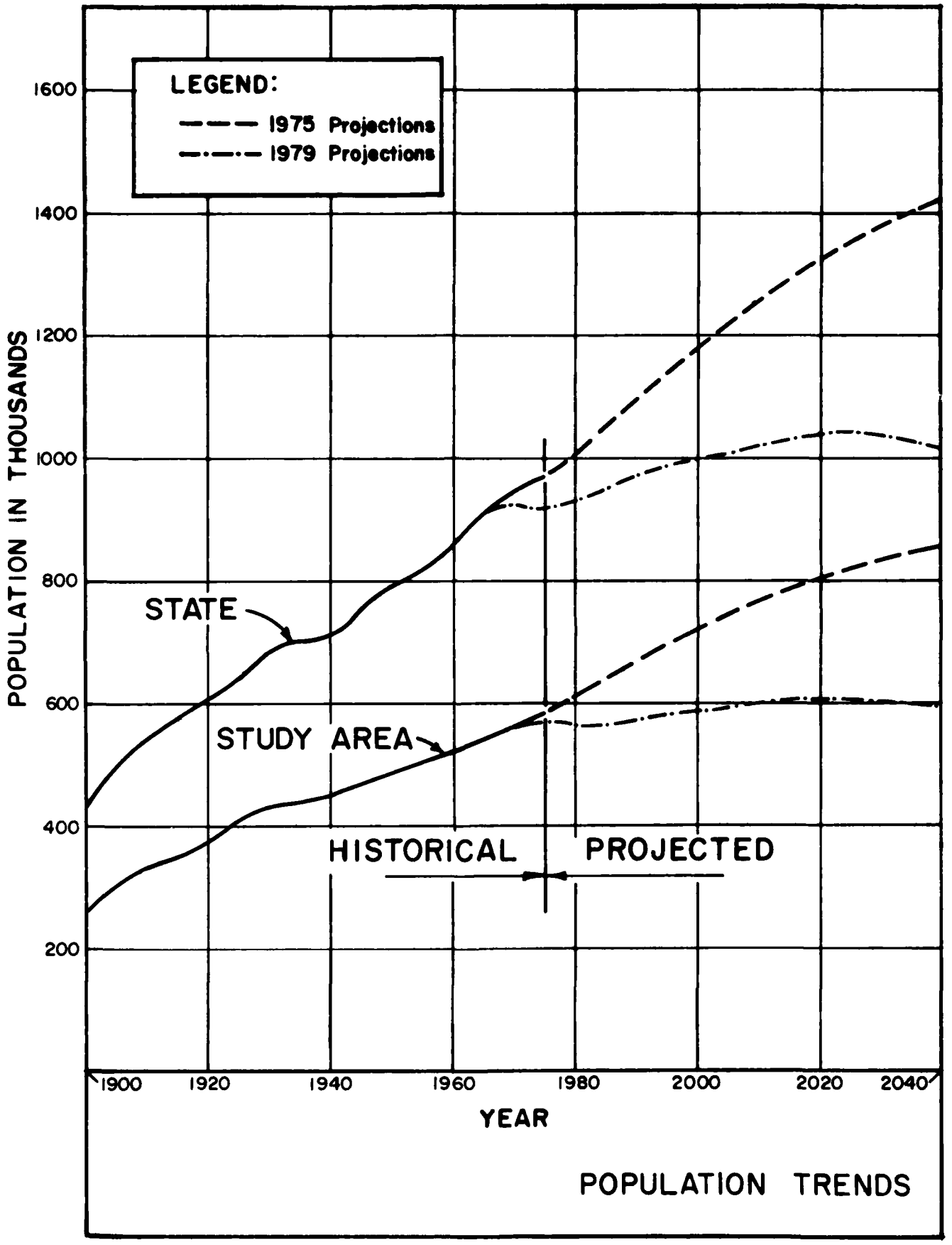
The April 1975 population projections were utilized by the Corps of Engineers to project future conditions for the study area during the early stages of this study, and for other water resources investigations then being undertaken for the entire PNB area.

In 1979, revised population projections were developed by the Statewide Planning Program which showed marked differences from the 1975 projections, due mostly to the projected birth rates assumed for the State. The revised projections show reductions from the 1975 forecasts of about 19 percent and 27 percent in the population of study area communities, in the years 2000 and 2030 respectively. State population figures show similar reductions of 14 and 25 percent respectively for the years 2000 and 2030, when compared to 1975 figures. Plate 4 shows the two projections for both the study area and the State.

Because the differences between the 1975 and 1979 Statewide Planning Program projections were so significant, these forecasts were compared with OBERS Series E projections developed by the U.S. Water Resources Council. The OBERS projections are only available for the entire State or the Providence-Warwick-Pawtucket Standard Metropolitan Statistical Area (SMSA), which is somewhat larger than the study area, including all of Providence, Kent and Bristol counties. However, this SMSA was considered similar enough to the study area in economic and land use factors that comparison was considered valid between the different population projections, when adjusted for the size of the area.

Population and economic projections based on OBERS projections are normally used to develop future conditions in planning Federal water resources development programs. However, the State of Rhode Island requested that Statewide Planning figures be used in this study to aid in coordination with existing State plans. Thus, the OBERS projections were used only to help in assessing the Statewide Planning projections. Table 3 shows projected population for the study milestone years according to the three different population projections.

The population projections developed by the Statewide Planning Program show such a large disparity between them that a choice had to be made as to which series, 1975 or 1979, would more accurately reflect future conditions. When compared to the OBERS projections, the 1975 Statewide Planning figures are much closer to the trends projected by OBERS. Likewise the 1975 projections reflect more closely the degree of development anticipated in the State Guide Plan, which provides guidance for future development of the entire state. In addition, the 1975 projections reflect a conservative approach to future conditions that is normally utilized in water supply planning. Unforeseen changes in future conditions, such as major new industries or reduction in supplies through contamination, could thus be accommodated by whatever water supply plans are developed. Thus the 1975 population projections were felt to represent the most probable future condition as the basis for determining water resources development needs of the study area.



POPULATION TRENDS

Source: R.I. STATEWIDE PLANNING PROGRAM

PLATE 4

TABLE 3

COMPARISON OF POPULATION PROJECTIONS

RHODE ISLAND STATEWIDE PLANNING PROGRAM

	1975		2000		2030	
	1975 [1] Projection	1979 [2] Projection	1975 Projection	1979 Projection	1975 Projection	1979 Projection
Total Study Area	579,500	571,300	726,600	590,700	833,400	605,300
Total State	952,200	936,300	1,173,600	1,005,600	1,377,800	1,040,000

1 Rhode Island Statewide Planning Program, Technical Paper No. 25, April 1975

2 Rhode Island Statewide Planning Program, Technical Paper No. 83, April 1979

	OBERS SERIES "E"				
	1970	1980	1990	2000	2020
Providence - Warwick - Pawtucket SMSA [3]	770,800	832,300	890,700	945,500	1,046,600
Total State	951,000	1,031,600	1,115,200	1,191,700	1,340,800

Source: 1972 OBERS Series E Projections, U.S. Water Resources Council
Note: OBERS projections not available for 2030.

3 SMSA is somewhat larger than study area; includes all study area communities and Burrillville, North Smithfield, Woonsocket, Cumberland, Lincoln, Central Falls and Pawtucket.

In Rhode Island, continued economic development is important to allow change and expansion while meeting environmental objectives. Economic projections are based upon an objective analysis of past trends. Over recent years, the economy of the State has changed considerably, with a decline in the manufacturing sector and increase in the service-oriented sector.

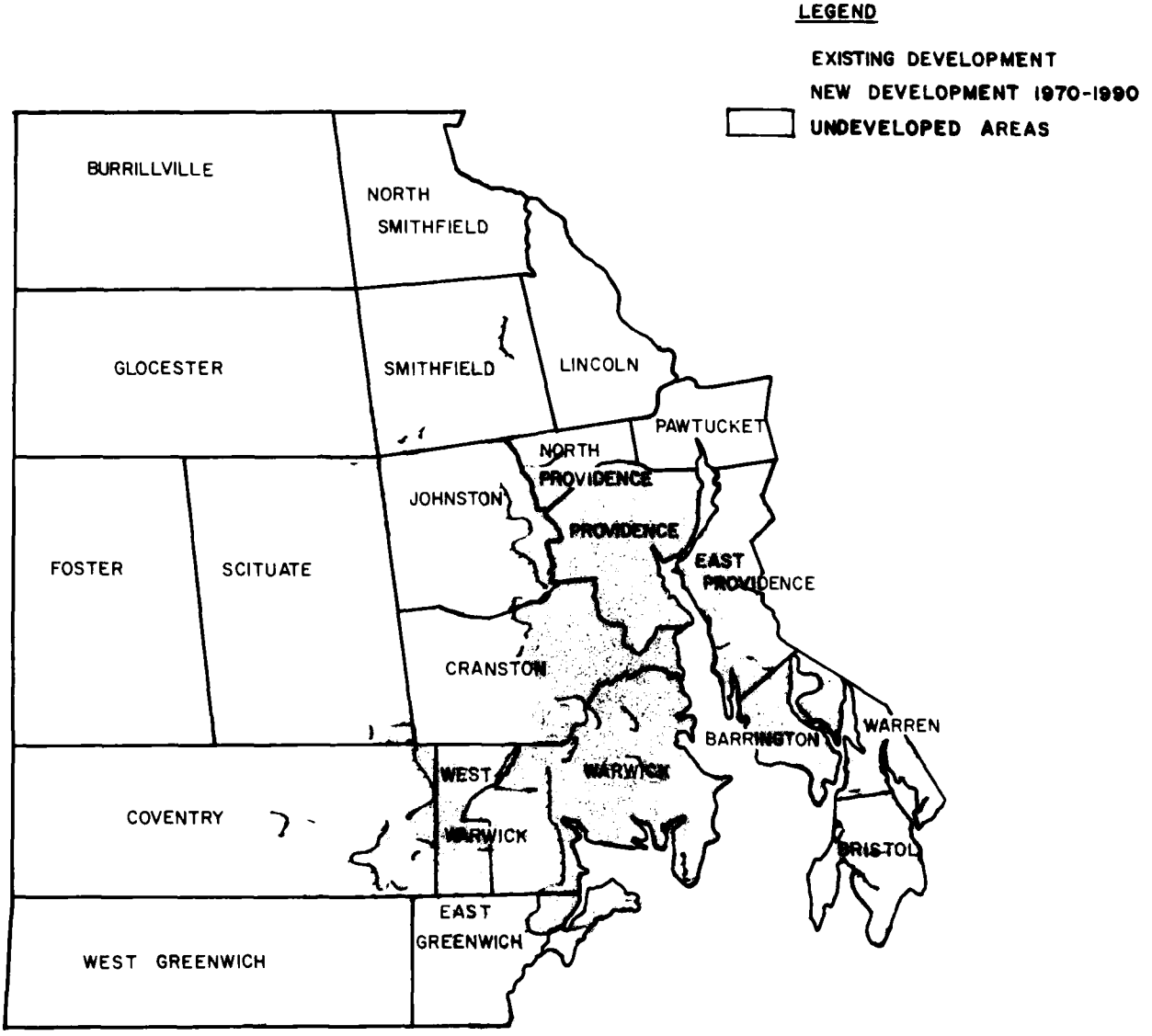
Economic projections for Rhode Island show a continuation of the present shift from a manufacturing-based economy to more dependence on the service sector. The Providence metropolitan area is also expected to experience steady growth, with a similar trend, a service oriented economy.

Land use projections for 1990 show a significant increase in residential land use, from 16.6 percent in 1970 to 26.1 percent predicted for 1990. Forest and open land show a significant decrease, from 70.2 percent in 1970 to 51.9 percent in 1990. The only other notable land use change is in recreation lands, which increases from 1.0 percent in 1970 to 7.8 percent in 1990. The remaining land use categories show little projected change during the 20-year period. Projected development trends are shown on Plate 5.

The projections described above form the basis for the overall projection of the without condition profile, which provides the information to enable a comparison between plans and allows evaluation of each plan's impacts. The following discussion profiles conditions in the study area related to water supply, flood damage reduction and recreation.

Existing water supply management programs would be expected to continue for the foreseeable future, with the agencies relying on existing sources of supply to meet any future demands. Only the Bristol County Water Company would be expected to augment its present system, as there is an immediate need for additional supplies to meet existing demands on that system. Bristol County has faced shortages over the past several years, and has had to place restrictions on users during high demand periods. To meet its present and projected future needs, the Bristol County Water System would obtain additional supplies through phased development of surface and ground water resources in Rehoboth, Massachusetts, as well as improvements to existing facilities.

The Providence metropolitan area would continue to be served by the Providence Water Supply Board and Kent County Water Authority systems, utilizing existing surface and ground water supplies. When water demands exceed the available supplies, shortages would begin to occur throughout the service area for these regional systems. Various social, environmental and economic effects would be faced by municipal and industrial water users due to water shortages or inadequate system capacity.



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

DEVELOPMENT TRENDS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 5

In less urbanized outlying communities in the study area, private on-lot systems would continue to be utilized until such time as municipal systems become appropriate due to growth of the towns. Privately supplied industrial users could be expected to continue to utilize present resources to satisfy their needs.

The Big River Management Area, site for the proposed Big River Reservoir, would remain undeveloped for the foreseeable future. State and local water resources agencies would be unable to fund construction of such a project without public financing, which has historically been extremely difficult to obtain. In addition, the site may become unsuitable for public water supply use should encroachment on it occur. The Big River site, presently a rural, undeveloped area, is not regularly monitored by State officials to ensure continued compatability with future water supply development there. The chance of long-term contamination of the site through hazardous or other wastes, which would effectively eliminate it from future water supply planning considerations, will increase with time as population and development pressures on the area continue.

Average annual flood losses of about $1,429,000 (September 1978 price levels) would continue to result from flooding in the Pawtuxet River Basin. Both physical and nonphysical losses would be incurred due to damaged goods and property, lost wages and business income, and disruptions in utility service. Development in flood prone areas would continue to be regulated by the requirements of the National Flood Insurance Program.

Recreational demands in Rhode Island would continue to increase during the study time frame. Recreational demands within the study area would continue to be met by existing resources, except in the cases of boating and golfing facilities. However, demands on facilities in communities surrounding the project area would continue to increase.

PROBLEMS, NEEDS AND OPPORTUNITIES

Problems, needs and opportunities for the study area were derived from a combination of publicly expressed concerns and an analysis of the existing conditions and without condition profile. Water and related land resources needs thus compiled were reviewed to determine those appropriate for investigation under this study authority. Water supply, flood control, and recreation problems were included as project purposes. Hydroelectric power generation was investigated, but not included as a project purpose. An ongoing Corps study of small hydropower potential for New England is addressing the regional potential. Preliminary investigations of possible small hydropower installation at the proposed Big River Reservoir recommended that further investigations be deferred until a decision is made on construction of the dam, as hydropower installation has not been shown to be definitely cost-effective, and would only be a small part of the total facilities.

Several other possible water resource development features were ruled out after analysis of their applicability to this study. Wastewater management and low flow augmentation are water resources problems that have

been studied in a recently released report by the State, the findings of which have been acknowledged in this study. Investigations in these areas were felt to be duplicative, so they were not included as project purposes, and problems and needs in these areas were not directly addressed.

Water Supply

The existing conditions presented earlier showed that over most of the study area, additional water supply is not needed immediately, as system capacities are not presently being exceeded, with the exception of the Bristol County. However, projections of population and economic growth for the study area, making up the without condition profile, show that increasing water supply demands within the study area will exceed the capacities of all supply systems in the near future.

Projections of water demands were based on estimates of population, percentage of the population served, per capita consumption, and industrial water use. These parameters were projected based on historical data and assumptions of future growth trends. Population served was assumed to gradually increase until by 2030 the entire study area would be 100 percent served. Likewise, per capita consumption would increase over the entire study area, with rural area consumption growing by more than that of urbanized areas. Large increases in industrial water use are not expected to occur, as no major new industries are assumed for the study area. A complete description of the water demand projection methodology used is given in Appendix A, "Problem Identification."

The projected water demands for the study area, shown on Table 4, are based on the "most probable future" and the methodology outlined above. The table shows average day demands for the study area increasing from approximately 72 mgd in 1975 to almost 109 mgd in 2000 and to about 142 mgd by the year 2030. Based on the study area's base year safe yield of 91.1 mgd, deficits would thus be about 18 mgd and 53 mgd in the years 2000 and 2030 respectively.

Maximum day demands must also be met for a system to be considered adequate, and these demands will increase from about 124 mgd in 1975 to 190 mgd in 2000 and almost 250 mgd in 2030. With a maximum day capacity of the study area systems of 159.6 mgd in the base year, deficits of about 30 mgd by 2000 and 90 mgd by 2030 would thus occur.

The deficits described above are significant, and some action must be taken to meet the water supply needs of the study area by increasing supplies and/or reducing demands in the study area. Development of surface water and ground water resources are among the opportunities available for increasing supplies, and demand reduction could be addressed through water conservation techniques.

Flood Damage Reduction

Flooding in the Pawtuxet River Basin, which occurs primarily from runoff caused by precipitation of high intensity or prolonged duration, has

TABLE 4

MUNICIPAL WATER SUPPLY REQUIREMENTS FOR STUDY AREA 1)

WATER SUPPLY AGENCY	COMMUNITIES SERVED	1975 SOURCES OF SUPPLY	1975 SAFE YIELD, MGD.	MAXIMUM DAY CAPACITY, MGD	1975 AVERAGE DAY DEMAND, MGD.	1975 MAXIMUM DAY DEMAND, MGD.	2000 AVERAGE DAY DEMAND, MGD.	2000 MAXIMUM DAY DEMAND, MGD	2030 AVERAGE DAY DEMAND, MGD.	2030 MAXIMUM DAY DEMAND, MGD
Bristol County Water Company	Barrington	G. W.	0.7	0.7	1.0					
	Bristol	S. W.	2.5	4.0	2.4					
	Warren									
			3.2	4.7	3.4	5.8	5.3	9.2	6.9	11.9
Providence Water Supply Board	Cranston									
	Providence									
	Johnston									
	North Providence									
	East Providence									
	Smithfield									
	Warwick									
		S. W.	77.0	144.0	62.4	106.0	91.0	155.4	117.4	200.5
Kent County Water Authority	East Greenwich									
	West Greenwich									
	Coventry									
	Scituate									
	West Warwick									
		G. W.	10.9	10.9	6.0	12.4	12.0	24.4	16.9	34.5
	Foster	none	0	0	0	0	0.2	0.3	0.4	0.9
	Glocester	none	0	0	0	0	0.4	0.7	0.8	1.7
Total Study Area			91.1	159.6	71.8	124.2	108.9	190.0	142.4	249.5

1) Based on 1975 population projections
G.W. - denotes groundwater
S.W. - denotes surface water
MGD - denotes million gallons per day

adverse effects on the economy and general well-being of the flood prone areas. Flooding causes physical damage to property, nonphysical losses associated with interruptions of commercial, industrial and public activities, loss of business and personal income, and also threatens the health and safety of residents and workers in flood prone areas.

The possibility of flooding exists year-round in the Pawtuxet River Basin. The headwaters of both the Scituate Reservoir, which feeds the North Branch of the Pawtuxet River, and the Flat River Reservoir, which provides flow for the South Branch of the Pawtuxet, are rural in character and support only minimal development in their flood plains. Because of the hilly topography and steep stream profiles the areas upstream of the Scituate and Flat River Reservoirs experience only moderate increases in river stages during periods of heavy rainfall and runoff.

The magnitude and timing of releases of water from Scituate and Flat River Reservoirs as well as rainfall and resulting runoff downstream of both reservoirs impact on flooding problems on the mainstem and the North and South Branches.

Historical data on flooding in the Pawtuxet River Basin dates to the early 1800's. Throughout this period numerous flood producing storms have been experienced by the region, but the area has not suffered high monetary losses. However, the continuing trend of urbanization in the basin has left the basin vulnerable to severe flood losses.

Increased urbanization in the Pawtuxet basin is projected in the "most probable future" and will result in increased development of non-flood plain areas. This development will cause increased rates of runoff, resulting in higher flood stages than previously experienced. Thus, flood prone areas can expect more frequent and severe flooding than before, and a significant worsening of the flood problems in the basin.

Principal flood damage areas are located along the mainstem Pawtuxet in West Warwick, Warwick and Cranston. The most significant damage areas are at the West Warwick Industrial Park, Ciba-Geigy, Inc. industrial complex, the Norwood-Belmont residential area, Bulova industrial complex and the Warwick and Midland shopping malls and surrounding stores and apartment complex.

Moderate damages could be expected at the Wellington Avenue Industrial Park, Jefferson Avenue Industrial Park, and the Pontiac Mills industrial complex. Other locations within the basin subject to damages are at the West Warwick, Warwick and Cranston municipal wastewater treatment plants (these plants are presently undertaking protection measures individually), and areas along Meshanticut Brook and the Pocasset River, tributaries influenced by flooding on the mainstem Pawtuxet.

The effects of increased urbanization in the upstream communities will be felt in downstream areas, and increased damages will occur even without new development in the flood prone areas. Flood losses, based on projected 1990 conditions, are estimated at over $3,650,000 for a 20-year frequency

flood and over $5,470,000 for a 50-year event, at September 1978 price levels.

Opportunities for flood damage reduction exist by both structural and nonstructural means. Flood control storage at upstream reservoirs and local protection projects are some structural methods available for reducing damages, and flood proofing, relocation and regulatory measures are among the nonstructural techniques which could be utilized.

For further information on flooding in the Pawtuxet River Basin, see "Attachment 1."

Recreation

Recreation demands of the study area were investigated to determine the need for additional facilities which could be incorporated in water resources development plans. Three use areas were examined, including the site of the proposed Big River Reservoir, the local communities surrounding the Big River site and the entire State of Rhode Island.

Estimated demands for recreation, for each of the use areas, is shown on Table 5, along with the existing supply capacity. Projections were developed for the years 1995 and 2020, and show that the most significant needs on a statewide basis are for boating, camping, golfing, hunting, picnicking, and swimming facilities. Recreation demands for the local area and on-site are not nearly as significant and center on the addition of boating, golfing and picnicking facilities.

Rhode Island is a small state, and only a relatively short travel time is required to reach even the most distant parts of the State. Thus, in developing recreational facilities alternatives as part of the overall water resources plans for the study area, satisfaction of statewide needs was considered a prudent approach.

Recreational facilities development opportunities are available in conjunction with other water resources development plans by utilizing the environmental features of lands acquired for the other development.

For a detailed discussion of recreation demands of the study area, and plans for meeting these demands, see Appendix H, "Recreation and Natural Resources."

Alternative Projections - Sensitivity Analysis

As noted in the Without Condition Profile, significant differences exist between the 1975 and 1979 Statewide Planning Program population projections for the study area. Projected water supply demands based on the population projections likewise show significant variations between the two projections. Average day demand in 2030 based on the 1979 projections would be about 109 mgd, or a 23 percent reduction from the 142 mgd figure based on the 1975 projections. Maximum day demands would be similarly affected, with 2030 maximum day demands reduced by 24 percent, from 250 mgd

TABLE 5

ESTIMATED RECREATION DEMANDS
(Persons per day)

ACTIVITY	SUPPLY CAPACITY 1)	PRESENT DEMAND	1995 DEMAND	2020 DEMAND
BOATING				
State	46,471	19,426	34,491	77,614
Local	770	657	1,451	3,341
Big River	342	45	90	207
CAMPING				
State	17,104	14,854	20,936	28,607
Local	2,864	128	180	247
Big River	0	0	0	0
FISHING				
State	26,308	5,939	8,358	11,375
Local	6,176	330	464	632
Big River	360	100	128	174
GOLF				
State	11,328	5,951	10,883	22,462
Local	1,008	793	1,450	2,579
Big River	144	175	286	509
HIKING				
State	17,847	4,534	6,333	9,824
Local	6,210	50	70	94
Big River	2,700	10	13	17
HORSEBACK RIDING				
State	11,940	2,543	4,679	8,370
Local	2,050	55	101	181
Big River	1,500	20	33	59
HUNTING				
State	6,000	2,326	4,160	7,687
Local	3,290	115	206	380
Big River	1,600	100	165	304
PICNICKING				
State	32,047	51,951	58,300	59,881
Local	2,655	2,420	2,627	2,698
Big River	0	100	101	104
SWIMMING				
State	53,792	50,501	74,466	107,777
Local	8,089	2,633	3,883	5,619
Big River	9,450	200	277	401

1) "Supply Capacity" refers to the maximum number of persons which ideally can utilize existing recreational facilities each day. The estimated demands given are based on the "design day demand" which refers to the estimated number of persons wishing to participate in a certain recreational activity on a peak day.

to 191 mgd, when based on the 1979 population projections as opposed to the 1975 projections.

The reduced growth indicated by the 1979 projections when compared to the 1975 projections would probably have some effect on flood plain growth thus affecting growth in future flood losses. However, flood damage reduction needs already exist in the Pawtuxet Basin, so any change in population projections would not delay the need for any proposed flood damage reduction measures.

Recreation needs would probably be reduced to some extent should the reduced population projections hold. However, the effect on the timing of any proposed facilities is difficult to estimate due to the nature of the recreation needs.

PLANNING CONSTRAINTS

Planning constraints are those conditions imposed upon the planning process that limit the range of feasible alternatives available to the planner. These constraints may be legal, public policy, economic, social or environmental factors of such importance that to violate them would compromise the entire planning effort.

One public policy constraint on the planning process results from the State's purchase of lands in the mid 1960's for reservoir development. These State-owned lands include the proposed Big and Wood River reservoir sites. As these lands are already targeted by the State for reservoir development, the selection of other sites would be contrary to existing State planning. In addition, the existing system serving the metropolitan Providence area has been designed for an eventual connection from the Big River Reservoir, and major modifications to the system might be necessary should another alternative be adopted.

PLANNING OBJECTIVES

The final array of planning objectives was derived from an analysis of the water and related land resources problems and needs of the study area in relation to the most probable alternative future and reflects several iterations of the planning process. Thus, the planning objectives provided the basis for formulation of alternative water resources plans. The planning objectives address the water supply, flood damage reduction, and recreation needs of study area communities, including a thorough evaluation of technical, economic, environmental and social concerns. They evolved through interaction with the public and other agencies during the course of the study.

Objectives addressing water supply management were directed at preservation of existing resources, flexibility in the development of additional supply sources, and conservation of both municipal and industrial water usage. Objectives addressing the associated environmental needs of water supply management were directed principally at protection of

unique natural areas, conservation of wetlands values and fish and wildlife resources, and enhancement of human use value of the area's natural resources.

Objectives addressing flood control and flood plain management in the study area were aimed at reduction of flood damages resulting from increased development in the Pawtuxet River Basin and provision of both structural and nonstructural solutions. Objectives associated with environmental needs were directed at preservation of existing stream conditions since no highly productive habitat exists in the Pawtuxet River Basin as a result of the urbanized nature of the watershed.

Comprehensive recreational resource enhancement was considered in view of the diversity of recreational needs within the study area and the State. Planning objectives were directed at enhancement of the value of human use of natural resources in compatibility with the environment.

Wastewater management and water quality problems in the study area were considered under programs of other Federal, State and local governmental agencies and were not addressed in this study except as they related to development of other water and related land resources.

The specific planning objectives developed for the study area are as follows:

Water Supply

. Contribute to the preservation of existing surface water and ground water resources to meet short-term (2000) and long-term (2030) needs of the study area.

. Contribute to the modification of water usage within the study area to optimize existing resources and to meet short-term (2000) and long-term (2030) water demands.

. Contribute to the development of additional ground water and surface water resources to meet the projected short-term (2000) and long-term (2030) municipal and industrial water supply needs of the study area.

. Contribute to the conservation of wetlands values and fish and wildlife resources in the study area through protection and enhancement of other lands during the study time frame (1980-2030) and beyond.

. Contribute to the protection of unique natural areas in the study area during the study time frame (1980-2030) and beyond.

Flood Damage Reduction

. Contribute to reduction of the flood hazard and associated urban flood damages in Coventry (South Branch) and in West Warwick, Warwick and Cranston (Pawtuxet River) during the study time frame (1980-2030) and beyond.

. Contribute to the preservation and maintenance of the resources of existing stream environments within the study area during the study time frame (1980-2030) and beyond.

Recreation

. Contribute to recreational opportunities in the Big River Reservoir area during the study time frame (1980-2030) and beyond.

. Contribute to the preservation of water quality in the Big River Reservoir through discreet siting of recreational resources during the study time frame (1980-2030) and beyond.

. Contribute to the enhancement of the value of human uses of natural resources within the study area during the study time frame (1980-2030) and beyond.

FORMULATION OF PRELIMINARY PLANS

In this section, a broad range of management measures are identified and examined. Plans of other agencies that address our planning objectives are considered. After analyzing the measures with specific technical, environmental, social, and economic criteria, the surviving measures are combined into a range of water resource plans. The preliminary alternatives are compared to each other to ensure a broad mix that addresses the national and planning objectives established for the study. The plan formulation process and evaluation criteria are presented in detail in Appendix B, "Plan Formulation."

PLAN FORMULATION RATIONALE

Before discussing the plans that resulted from the preliminary plan formulation, a brief summary of the formulation process and the evaluation criteria used is presented here to brief the reader on the screening process used to arrive at the best alternative plans.

First, all possible measures for meeting the study objectives were identified. Those measures that were obviously infeasible or unacceptable were removed from further consideration in the preliminary screening. The remaining measures were arranged into various plans to meet the study area's needs. The plans were then compared and evaluated according to the criteria presented below, with the results being the formulation of a set of preliminary single-purpose plans for water supply and flood control.

Recreation plans were developed similarly to those for water supply and flood control, except that they were limited to those plans that could act in conjunction with possible development of Big River Reservoir.

As the preliminary plans were formulated separately the preliminary plan formulation section is arranged into three parts by project purposes. Formulation and evaluation criteria are common to all purposes, and are presented in a single section. This section is followed by three sections, one for each project purpose, which present management measures and preliminary plan formulation for each project purpose. The results of the formulation of preliminary plans are then combined into the detailed plans and presented in the Assessment and Evaluation of Detailed Plans.

Formulation and Evaluation Criteria. Selection of a plan of improvement which represents an acceptable and justifiable solution that best responds to the problems and needs of the area entails the application of technical, economic and social criteria to all possible alternatives, including consideration of all beneficial and detrimental effects on the area's environment.

Basically, the plan must be economically sound with a benefit-to-cost ratio of at least one. It must be technically feasible and complete in itself to fulfill the intended purpose. The environmental and social

impacts of any plan must be fully accounted for and analyzed, and management actions to enhance environmental quality should be identified. The public views about a plan must be positive before it can be selected for implementation.

Evaluation criteria are applied broadly at first and then in more detail as plan formulation proceeds towards the selection of detailed plans. A more complete description of the plan formulation process and the formulation and evaluation criteria can be found in Appendix B, "Plan Formulation."

WATER SUPPLY

Management Measures

In formulating alternatives an array of potential measures was investigated. These included nonstructural and structural measures and a No Action plan. Table 6 lists the measures considered in this initial screening.

TABLE 6

WATER SUPPLY MANAGEMENT MEASURES

No Action Program

Nonstructural Measures

1. *Demand Modification*
2. Weather Modification
3. Direct Wastewater Reuse

Structural Measures

1. Surface Water Resources
2. Ground Water Resources
3. Importation
4. Dual Water Supply Systems
5. Desalination
6. Iceberg Harvesting

No Action. The No Action alternative assumes that the present base condition would continue, with no action taken by any water supply agency or individual community to augment supplies or reduce consumption. By the year 2000 all study area communities would experience deficits in water supply. Significant socioeconomic and environmental impacts would thus result from a no action program in addition to nonattainment of the planning objectives for water supply management. Thus such a program was not seen as a realistic solution to the study area's water supply problems and was dropped from further consideration.

Water Demand Modification. When the demand for water increases, the usual response is to construct new waterworks facilities. However, an alternative approach is to reduce demand in conformance with available supplies. Following are five methods which have been suggested as effective in controlling demands on water supplies:

1. Pricing policies (changing rate structures).
2. Installing water saving devices.
3. Water conservation education programs.
4. Imposing restrictions on water use.
5. Controlling water system losses.

Each of these methods may be used singly or in combination to achieve a reduction in total water use. The reduction may be an absolute one, in which demand is less than before implementation, or it may be a reduction in the rate of increase of water use.

Rate structures may be changed in several ways. Some alternative pricing policies include spatial differentation of prices, seasonal pricing, increasing block rates, and average variable cost pricing.

Water saving devices reduce flows from showers, lavatories and toilets to the minimum necessary to accomplish their purpose. Flow reducing devices can be added to existing fixtures, or replacement fixtures designed to reduce flows can be installed. Some flow reducing devices currently in use include water saving toilets, reduced flush devices, flow limiting shower heads, water conserving dishwashers and clothes washing machines, flow control devices for faucets, and pressure reducing valves to reduce unnecessarily high system pressures.

Modification of water use attitudes and habits can reduce consumption significantly. Education and information campaigns directed toward the consumer can bring about reduced waste in water usage by the voluntary efforts of the educated consumers.

Institutional restrictions are administrative and legislative controls which can be implemented by water suppliers and government agencies to insure public welfare during times of water supply shortages. Some institutional restrictions applicable to the study area are restrictions on domestic water use, water rationing, building and plumbing code restrictions, industrial reclamation and reuse, maintenance water control, inspections, fire hydrant use restrictions, and landscape watering restrictions.

Control of water system losses can be accomplished by a program of leak detection and repair, metering of the entire system, and reduction of illegal uses, such as opening of fire hydrants.

Weather Modification. The primary focus of research in this field is cloud seeding, although long term seasonal precipitation forecasting and

fog drip augmentation are also being studied. However, only cloud seeding is applicable to the Rhode Island area.

Rain falls from clouds when water vapor in the clouds condenses around particles and forms rain drops large enough to overcome frictional resistance to falling. Cloud seeding is based on the introduction of foreign particles, such as dry ice and silver iodide, into clouds to enhance condensation, producing rain.

Several studies have been made on the feasibility of cloud seeding as a means of augmenting water supplies. The results show that weather modification is an inexact science at best, with much refinement needed before it can be considered a reliable method, and with its ultimate feasibility questionable. Thus, weather modification operations do not appear to provide a viable solution to the study area's water supply problems in the near future.

Direct Wastewater Reuse as a Municipal Supply. Direct wastewater reuse involves returning the effluent from sewage treatment facilities to industrial or municipal supplies. Advanced treatment techniques would be used to make the effluent safe for human consumption.

Direct wastewater reuse has been successful in industrial process applications in some parts of the country. However, its use for drinking water supply is still lacking in much basic research, and many questions remain. Until this research is completed and appropriate technology is developed, direct wastewater reuse is not a viable alternative to the study area's water supply needs.

Surface Water. Surface water development may be by drafting or impounding streamflow. Larger rivers and lakes may be drafted continuously, while smaller streams may be drafted during high flows, depending upon the demand and the source's ability to meet it.

Impounding reservoirs, generally on upland streams, may be the most desirable method of supply. Water quality is generally better than from other methods of surface water development, thus treatment is not always necessary, and supply can usually be by gravity flow through aqueducts.

Ground Water. Ground water storage comprises most of the fresh water storage in the United States by far, and is commonly tapped for water supplies by wells. The most commonly used type is the drilled well, particularly for deep wells when other types are not feasible. Water supplied by wells is generally less likely to need treatment than surface water and is considered less expensive to develop in most cases.

Importation. This technique involves the diversion of ground water or surface water supplies from watersheds outside the study area to augment existing supplies. In some cases the diversion would be made from existing sources that are expected to be otherwise underutilized over the

long term. In other cases, the diversion could be made from presently undeveloped sources.

Dual Water Supply Systems. These systems establish a hierarchy of water uses, with higher quality supplies furnished for drinking, cooking, dishwashing, cleaning, bathing and laundering. Other uses would be satisfied by a lesser quality supply.

Dual systems could work by recycling water at the point of usage, with effluent from higher-level uses treated and used for lower level purposes. A second approach would involve using two distribution systems to accommodate the two supplies. Potential health problems are inherent in any system that introduces less than potable water into the home environment. This factor, when combined with the high capital cost of dual water supply systems, precludes the use of such systems in the study area.

Desalination. Desalination, the process by which brackish and saltwater is converted to fresh, is currently being used in some parts of the world as an economically feasible source of fresh water. There are four major processes for desalination: distillation - evaporation, membrane separation, crystallization, and chemical differentation. Distillation and membrane separation are most applicable to large-scale operations, according to the present state of the art.

Desalination is already feasible in certain parts of the world where the natural water supply is either scarce or of poor quality, and the relatively high cost of desalination is justified. However, in the study area desalination process costs are much greater than that of possible surface and ground water developments in the study for the near future. Thus, desalination was ruled out as a solution to the study area's short term water supply problems.

Icebergs. Recent proposals have been made to transport slab icebergs from the polar regions to areas with water shortages. An iceberg would be towed by ocean-going tugboats to the needy area, where it would be melted.

There are many technological problems involved in the use of icebergs as a source of drinking water. These problems must be addressed to bring the high cost of this technology into line with conventional sources, which will not occur until costs from conventional sources increase a good deal. This process does not appear feasible for the near future and was ruled out as a solution to the study area's water supply problems.

Results of Preliminary Screening. The potential measures were evaluated at the outset to rule out those which could not meet even broad criteria for economic feasibility, engineering practicality, social and environmental acceptability, or adequacy as a solution. The preliminary screening showed that demand modification, surface water development, ground water development, and importation warranted further evaluation.

The No Action plan was not considered an appropriate response to the study area's water supply problems and was ruled out at this time.

Intermediate Screening. Those measures which passed the initial screening were considered in more detail before being combined into plans. Surface water and ground water sites for potential development were reviewed individually to determine those which would be most feasible to meet study area needs either separately or as part of an overall plan. Demand modification measures were screened to determine the overall effectiveness of such a program. Importation of surface water or ground water supplies from outside the study area was investigated as a part of an overall surface water and ground water site screening, and no distinction was made between sites inside or outside of the study area in the application of selection criteria.

The State of Rhode Island's prior purchase of lands for the Big River Reservoir site was recognized as a constraint to the selection of other possible surface water sites. However, ownership of lands was only used as a supplemental screening factor in conjunction with other criteria, and no sites were ruled out solely on the basis of land owernship.

a. Surface Water. Six surface water sites were considered for development in the northern part of the State, in the Blackstone River Basin, as shown on Plate 6.

The Chepachet River Reservoir site, located in Burrillville and Glocester, would yield 18.1 mgd but was dropped from further consideration when unfavorable foundation conditions were found at the dam site.

Smith-Sayles-Keech Reservoir, on the Chepachet River in Glocester, would be created by raising the spillway level of an existing dam. Further development of this site was ruled out when it was discovered that raising the spillway level would not increase the reservoir's yield due to increased evaporation losses. Moreover, the shallow depth of the existing impoundment and the extent of shoreline development around the reservoir caused this site to be dropped from further consideration due to unfavorable water quality.

Nipmuc River Reservoir and Tarkiln Brook Reservoir, located in Burrillville, were proposed as a system for staged development with a total yield of 15 mgd. The system is still considered technically and economically feasible, but only as a regional supply source for the northern part of the State. Transmission costs to the Providence system would be excessive compared to other alternative sites in the western part of the State, and new supply sources would have to be developed for the northern region, so this system was dropped from consideration.

Wilson Reservoir is an existing impoundment on the Clear River in the Blackstone River Basin. A diversion facility at the existing reservoir or a new dam to increase the yield were both rejected. New construction

would have unjustifiable costs, and the proposed diversion to Nipmuc Reservoir would not increase Nipmuc's yield, as all of Nipmuc's storage would be required to develop its own watershed. This site was thus dropped from further consideration.

Oak Valley Reservoir would yield about 6.3 mgd on Tarkiln Brook in the Blackstone River Basin. This reservoir appears to be technically and economically feasible, but would provide only local water supply benefits, so no Federal interest was found in the project and it was ruled out.

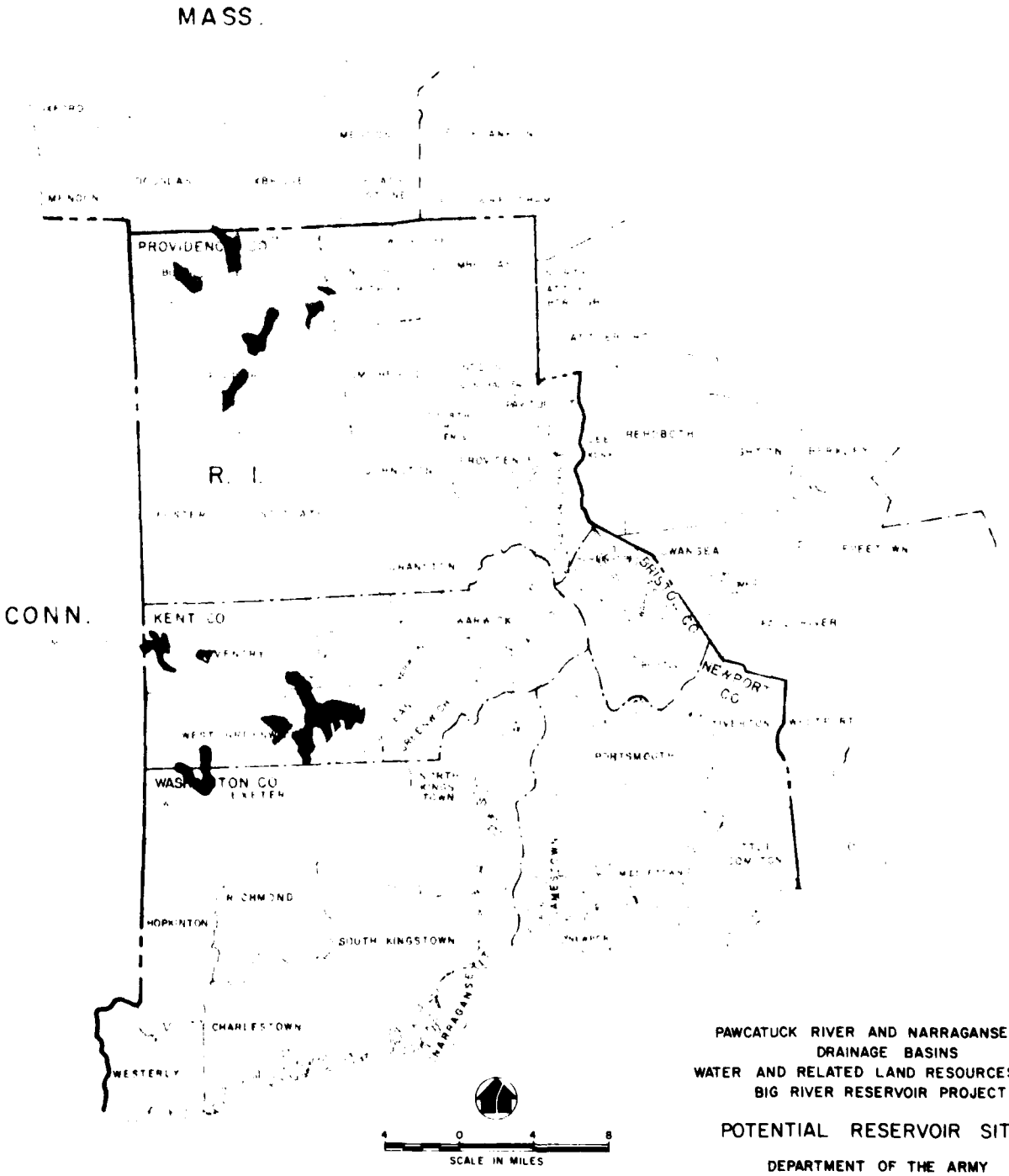
In the west central area of Rhode Island, systems involving six sites were examined to determine which alternatives could meet the study area's needs in the most efficient manner. See Plate 6 for the locations of the sites.

Nooseneck River Reservoir would be contained in the Big River watershed, yielding 7.1 mgd, and was considered for part of a system. However, the combined yield of a system with Big River Reservior would be less than 1 mgd greater than Big River Reservoir's yield alone, making the cost of Nooseneck River Reservoir unjustifiable. This reservoir was thus dropped from further consideration.

The Wood River watershed is contained in the Pawcatuck River Basin in the western part of the State. Proposed for development of this site was a diversion or reservoir as part of a system. The reservoir was rejected because the higher cost was not justified by the higher yield, and the environmental damage caused by the larger inundated area would be unacceptable due to the area's recreational popularity and fish and wildlife value. The diversion facility, which would yield 18 mgd, was reserved for further study as a part of a system.

Located on the South Branch of the Pawtuxet River, Flat River Reservoir is an existing industrial water supply reservoir. Development as an independent source of municipal water supply was rejected. The yield would not be sufficient to meet the study area's projected needs, requiring additional development elsewhere. Water quality of the reservoir would require extensive treatment, and land acquisition would be a problem if the privately owned reservoir were converted to water supply purposes. The flood skimming operation as a diversion would avoid some of these impacts at considerably less cost, and could provide 13 mgd yield, so it was retained for further study.

Big River flows into the southern end of Flat River. The proposed reservoir would be impounded just above the Flat River Reservoir and would provide 36 mgd safe yield. Big River Reservoir could be built independently to meet the area's short term needs and could also accept diversion flows from other sites. This proposal was carried forward for more detailed investigation.



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

POTENTIAL RESERVOIR SITES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 6

The Moosup River Basin is in the eastern part of the Thames River watershed, situated largely in Connecticut. A diversion facility would be located just over the State line in Connecticut, with the 17 mgd yield pumped into a storage reservoir nearer to Providence. The plan is considered feasible as a long range source for when other, cheaper alternatives are fully utilized.

Bucks Horn Brook flows westerly into the Moosup River and would be developed as a reservoir to be connected with the Moosup River transmission line. Considered feasible but expensive, this reservoir would not be developed until all other cheaper sources, including Moosup River Diversion, were developed.

The Bucks Horn Brook development was not carried forward for further study, although deemed feasible, because it would not be utilized until beyond the study time frame, if at all.

b. Ground Water: Investigations of local ground water showed no significant resources in several of the study area communities, and limited yields coupled with potential poor water quality in some of the others. Most of the remaining ground water resources are already developed. However, the towns of Foster and Glocester could develop sufficient ground water in Glocester and Burrillville to serve local needs. The development of ground water in Rehoboth, Massachusetts to serve Bristol County appears viable, as Rehoboth has projected surplus ground water which could meet the needs of Bristol County. Institutional arrangements between the states and water systems would be the major stumbling block to implementation of such a plan. However, development of ground water to serve Bristol County was retained for further consideration.

Aquifers in Lincoln and Cumberland were estimated at a possible 20 mgd. However, this ground water is of unacceptable quality, due to induced infiltration from the highly industrialized Blackstone River. Thus, this area was ruled out as a source for study area water supply.

In the southern part of Rhode Island, large amounts of ground water appear to exist in the Pawcatuck River Basin. An estimated 45 mgd yield could be obtained from aquifers there. However, this estimate would have to be reduced, possibly substantially, if water is to be exported from the basin, to avoid potential stream drying up. The communities in this region are experiencing strong growth pressures that are expected to continue, so most, if not all, of the area supplies are expected to be utilized locally. In addition, transmission costs to the Providence system and the rest of the study area would be excessive, due to the long distances involved. Development of ground water in southern Rhode Island was thus ruled out as a source of supply for the study area.

c. Water Demand Modification: Results of water demand modification efforts have varied widely among different studies. Realistic estimates

of the effectiveness of various methods for the study area were developed and used in the screening process to determine the feasibility of each method.

The price of water in the study area is so low that pricing policy changes would have little, if any, effect on use, unless prices were greatly increased. However, increasing prices to reduce consumption would bring large excess revenues to water utilites in the area, and also cause undesirable social and economic impacts in the study area, so this method was dropped from further consideration.

Water conservation education and water saving devices are techniques that are generally pursued simultaneously. They were evaluated jointly, using case study data and information on the efficiency of appliances and techniques currently in use. It was determined that an estimated five percent reduction in consumption could be achieved by the use of these two techniques.

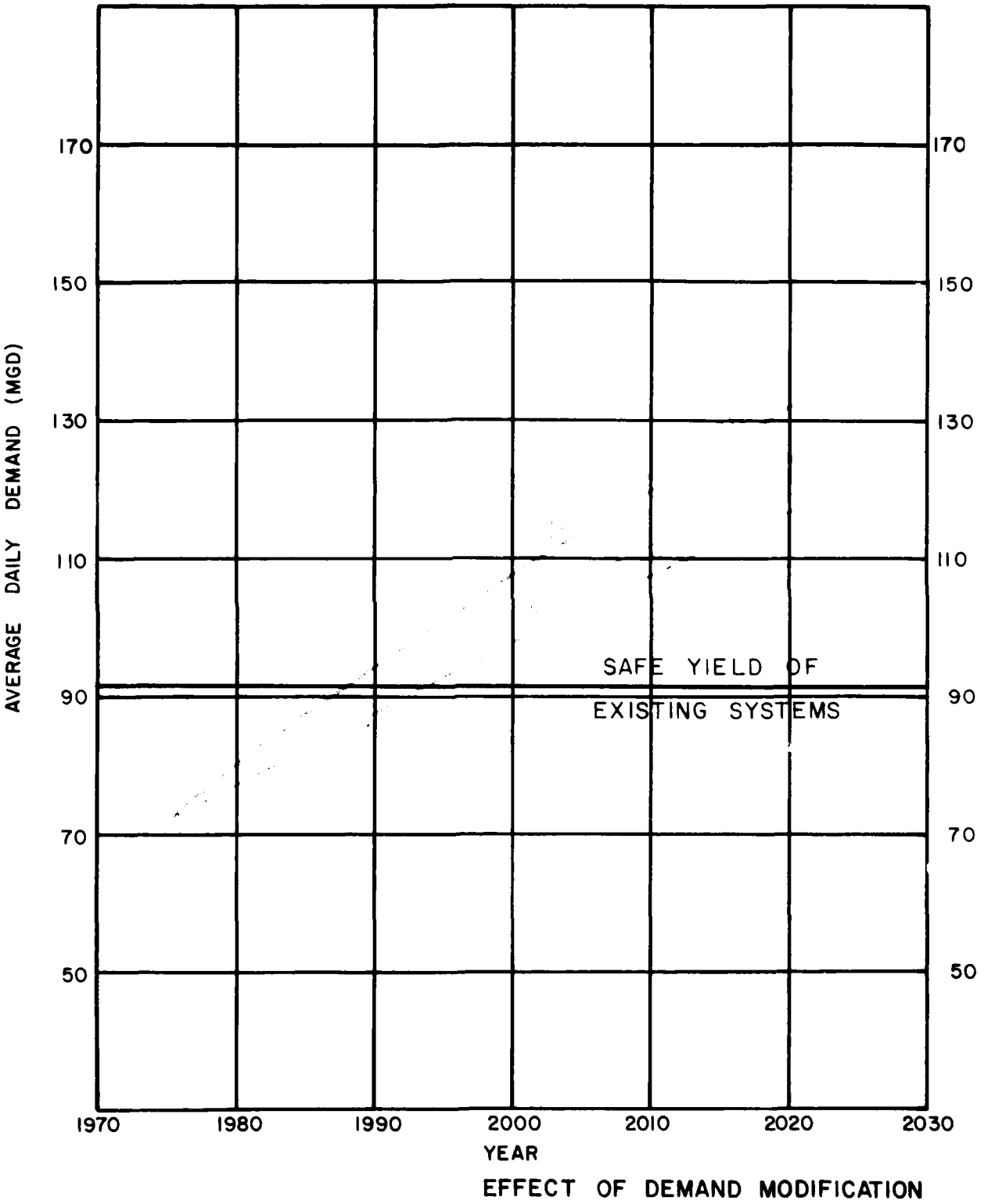
Institutional restrictions of the types mentioned earlier could reduce water use by around four percent by 2030. This estimate is based on building code restrictions and does not assume regular use of severe restrictions such as lawn sprinkling bans, since such restrictions would be imposed only during periods of severe shortages.

Due to the low amount of unaccounted for water in the Providence water supply system, the potential for reduction in consumption by leak detection and repair is small. A reduction of 2 percent is considered a reasonable estimate for the study area.

Aspects of the four techniques discussed above were deemed feasible for the study area. Additional reductions in demand could be achieved by utilization of other techniques discussed previously, but would only have a small effect on demand compared to a comprehensive program including water conservation education and water saving devices, building code restrictions, and leak detection and repair which is expected to reduce overall demand by approximately nine percent by 2000 and 11 percent by 2030. Plate 7 shows the effect of demand modification on the study area's water supply requirements. Unmodified demands are those projected to occur based on 1975 population projections. Modified demands show the reduction in projected demands resulting from the application of the demand modification techniques described above. The safe yield of existing systems in the study area is based on 1975 data and includes all municipal systems serving the study area.

For more detailed information on water demand modification, see Appendix B, "Plan Formulation."

d. Importation: The feasibility of importing water from other areas of the State to meet the needs of the study area was investigated as part of the surface water and ground water investigations. As noted in preced-



EFFECT OF DEMAND MODIFICATION

PLATE 7

ing paragraphs, several areas showed promise. Ground water development in Burrillville could help serve Glocester, allowing resources in that town to meet the needs of neighboring Foster. Rehoboth, Massachusetts has a surplus of ground water which could help meet existing deficits of Bristol County.

Results of Intermediate Screening. The intermediate screening of management measures showed that various surface water and ground water sites, both inside and outside the study area, could be feasible alternative solutions to the area's water supply problems. The effectiveness of demand modification was estimated for the study area, and this measure was also carried forward. Importation of supplies into the study area was deemed feasible in certain areas, and was studied under the surface water and ground water categories. For more detailed information on the screening of management measures, see Appendix B, "Plan Formulation."

Plans of Others

The Rhode Island Water Resources Board and the Providence Water Supply Board have adopted similar water resource development plans. The construction of Big River Reservoir to augment existing water supplies is a significant feature of both programs.

The State's Comprehensive Water Resources Development Plan, drawn up in 1967 for the Rhode Island Water Resources Coordinating Board, was developed in response to the drought conditions of the early 1960's and the attendant water supply problems experienced throughout the State. The plan outlines a time-phased water supply development program designed to meet projected water demands through 2020.

The principal features of the plan are:

1. The construction of the Big River Reservoir, a water treatment plant, and transmission mains which would connect with the existing Providence water supply system. This expansion would produce an initial 29 mgd of additional water supply. The plan also provides for flood skimming of Flat River Reservoir, Moosup River and Wood River and subsequent transfer to Big River Reservoir in order to augment the reservoir's yield.

2. The development of Tarkiln Reservoir, with a treatment plant and transmission mains to supply Woonsocket and the Blackstone Valley after 1990, followed by the development of a reservoir on the Nipmuc River prior to 2020.

3. The development of wells in the upper Pawcatuck River Basin and construction of transmission mains to Jamestown and Newport as well as development of additional wells in North Kingstown, as needed to meet the 2020 water supply requirements of the southern portion of the State.

4. In the eastern portion of the State the utilization of additional water supplies from Fall River, Massachusetts for North Tiverton and northern Portsmouth as they become available. Service would be provided to the southern part of Tiverton and Little Compton from Watson Reservoir.

5. The plan also discusses the possibility of using water from the upstream reservoirs of the Pawtucket water system to meet the needs of the northern part of the town of Cumberland.

In 1968 the Providence Water Supply Board adopted a water resource development program which set forth a variety of measures developed to augment and enhance the available water supply in the Providence Water Supply Board service area.

Four major points were outlined in the plan:

1. The immediate development of the Big River Reservoir, a water treatment plant, and transmission mains, followed by development of Wood River Reservoir in 1997 and Moosup River Reservoir in 2012. Development of these three reservoirs would ultimately add 64 mgd safe yield to the Providence Water Supply Board system. Flood skimming of Flat River Resevoir and development of Bucks Horn Brook Reservoir is proposed to meet water supply needs beyond 2018.

2. The development of Big River, Wood River, and Moosup River Reservoirs would lead to an estimated 6 mgd reserve capacity in the Providence water supply system in 2015. Therefore, consideration should be given to extending service to fringe areas to the east and south of the existing service area.

3. Water storage capacities at Aqueduct, Neutaconkanut and Longview Reservoirs should be expanded by 91 mgd by the year 2010.

4. The development of approximately 4.4 mgd of additional ground water by 2015 in Smithfield, Coventry and Glocester.

Analysis of Plans Considered in Preliminary Planning

Description of Plans. The measures that resulted from the preliminary and intermediate screening were then assembled into alternative water supply plans. Four basic alternatives were derived, with several measures common to some or all of the alternatives.

A program of demand modification would be undertaken in the study area in the manner described in the intermediate screening of management measures. Such a program would reduce average daily demands of the study area communities from approximately 109 mgd to 99 mgd in the year 2000 and

from about 142 mgd to 127 mgd by the year 2030. Maximum day demands would also be reduced, from 190 mgd to around 173 mgd in the year 2000 and from around 250 mgd to about 222 mgd by the year 2030. Although development of additional supplies would still be necessary to meet study area needs, demand modification would have a significant effect on the amount of additional development required.

The towns of Foster and Glocester have small projected demands, and are somewhat isolated from the existing systems in the study area. Local ground water development to serve these two towns was thus investigated, resulting in a plan to serve Foster with ground water from Glocester, which would then be served by an extension of the Pascoag Fire District, utilizing ground water in Burrillville.

Bristol County has an immediate need for additional supplies which cannot be met from sources within the Bristol, Barrington and Warren area. The most feasible method of obtaining the needed supplies for the short term, until any regional development is completed, was determined to be the development of ground water in Rehoboth, Massachusetts to meet Bristol County's needs through the year 1995. At that time, any additional supplies needed could be obtained through additional ground water development or through connection with a regional system.

The measures described in the above paragraphs were included in all of the intermediate alternatives, and are thus included in the costs of the alternatives. The major portions of the plans where differences occur are described below:

a. Alternative 1: Includes construction of Big River Reservoir initially, augmented by a flood skimming diversion at Flat River Reservoir by the year 2020. Big River would be developed to a maximum water supply pool elevation of 292.0 NGVD for a safe yield of 25 mgd. The flood skimming diversion at Flat River Reservoir would add 13 mgd to the system safe yield. Treatment facilities at Big River would be built with a capacity of 55 mgd. An additional 3 mgd of ground water supplies in Rehoboth, Massachusetts, would be developed in phases to meet the needs of Bristol County. Estimated construction cost of this plan, not including real estate or relocation costs, is $101,340,000.

b. Alternative 2: Includes development of Big River Reservoir to elevation 292.0 NGVD maximum water supply pool level. Flood skimming of the Moosup River, developed by 2020, would increase Big River's safe yield of 25 mgd by an additional 17 mgd. Treatment facilities at Big River would have a capacity of 60 mgd. The future needs of Bristol County would be met by construction of a transmission main and pumping station connecting the Providence system to the Bristol County supply system. Estimated construction cost for Alternative 2 is $125,610,000 not including real estate and relocations.

c. Alternative 3: Big River Reservoir would be constructed as in Alternatives 1 and 2, and a flood skimming diversion of the Wood River would provide 18 mgd, giving a total safe yield of 43 mgd. Treatment facilities at Big River and transmission facilities to serve Bristol County would be built as in Alternative 2. Construction cost of this alternative is estimated at $125,000,000, not including real estate or relocation costs.

d. Alternative 4: Big River Reservoir would be constructed with a maximum water supply pool elevation of 300.0 NGVD, providing 36 mgd safe yield. Treatment facilities would have a capacity of 55 mgd, and ground water development in Rehoboth, Massachusetts would serve Bristol County, as in Alternative 1. The estimated construction cost of Alternative 4, not including real estate and relocation costs is $99,630,000.

Comparative Assessment and Evaluation of Plans. The intermediate alternatives were studied to determine impacts of each. The various impacts were assessed to allow comparative evaluation of the alternatives, resulting in a selected alternative to be considered in the detailed multipurpose plan formulation.

All of the alternatives could be expected to create various impacts, both temporary and permanent. Air quality, noise levels and water quality would be adversely affected in construction areas during construction of structural measures. Construction activities would cause wind-blown dust and exhaust emissions from equipment, and dam construction would impact on water quality downstream unless precautionary measures were taken. All of these impacts would be temporary in nature.

Certain long-term impacts would be associated with all of the alternatives. Beneficial impacts include the provision of safe, dependable water supply to the study area, thus minimizing threats to public health and safety, social well-being and regional development, that are associated with water shortages. The demand modification program will reduce future demands allowing structural measures to be less intensively developed and thus less costly.

Adverse impacts of a long-term nature would be felt in the areas slated for reservoir development. Inundation of wetlands, forestland and open land would reduce wildlife habitat and recreational opportunities associated with these areas. However, mitigation measures would be undertaken to minimize these adverse effects. Demand modification would create few adverse social impacts as measures would be voluntary for the most part. However, structural measures for each plan would require the acqusition of real estate at each site and easements for construction of facilities.

Significant impacts associated with each of the four intermediate alternatives are presented below:

a. Alternative 1: Aqueduct construction by cut and cover methods would create both environmental and social impacts. Wetlands ecosystems and stream water quality would be adversely impacted and access to roads along the transmission route would be interrupted. These impacts would be temporary.

The Flat River flood skimming diversion would cause impacts on the area environment due to fluctuating pool levels, reduced downstream flows, and clearing for pumping station construction. Economic impacts would be felt by downstream water-using industries, due to the reduced flows. Another economic effect would be that, since droughts cannot be forecasted, much unnecessary pumping would be undertaken during normal operation of the flood skimming facilities.

Ground water development in Rehoboth, Massachusetts would entail temporary adverse environmental impacts which are not highly significant. Interstate institutional arrangements would be necessary, which could be a major social impact.

b. Alternative 2: Significant impacts of this alternative are similar to those under Alternative 1. Differences occur in the diversion facilities proposed and in the method of serving Bristol County.

The Moosup River diversion reservoir would eliminate some local cold water stream fishery, and reduced downstream flows would adversely effect aquatic resources below the dam. Interstate institutional arrangements would be required for the diversion of flows from an interstate river basin, as the Moosup River flows into Connecticut. Temporary environmental effects from construction include decreased water quality downstream and increased noise and dust in the area of the facilities. Social disruptions would occur in towns that the pipeline passes through.

The pipeline serving Bristol County from the Providence system would cause temporary impacts, during construction, interfering with shipping on the Providence River and affecting organic biota in the areas of all three river crossings. Local streets in the areas of pipeline construction would be detrimentally affected by construction.

c. Alternative 3: Impacts of this alternative are similar to those associated with Alternative 2, with the difference being that the diversion to Big River Reservoir would be from the Wood River watershed. Diversion facilities constructed on the Wood River would cause temporary degradation of water quality due to increased turbidity. Reduction of downstream flows by the diversion would have long term adverse water quality effects and would also affect stream habitat. Wildlife habitat would also be temporarily disrupted in the areas of pipeline construction.

d. Alternative 4: Impacts associated with this alternative are similar to those of Alternative 1. The major difference is that a flood skimming diversion at Flat River Reservoir would not be built, so the

adverse impacts associated with the diversion would not be felt. Big River Reservoir would be developed more extensively, but the larger reservoir would only cause minimal increased impacts over those already occurring at the site.

Conclusions

The impacts of the four alternatives, presented above, were analyzed and comparatively evaluated to determine the plan that would best fulfill the planning objectives and be most acceptable to the public. All four alternatives are feasible solutions to the area's water supply problems, but Alternative 4 emerged as the best choice.

Three of the alternatives required diversions in addition to Big River Reservoir to meet future needs. The land takings, construction activities, and institutional arrangements necessitated by the diversion proposed under Alternatives 1, 2 and 3 would create adverse environmental and social impacts not caused by Alternative 4, as well as being more expensive to implement than the provisions of Alternative 4.

Alternatives 2 and 3 were much more expensive than Alternatives 1 and 4, and would create more adverse environmental and social impacts, so Alternatives 2 and 3 were ruled out.

Alternative 1 also creates more widespread impacts than Alternative 4. The present recreational usage of Flat River Reservoir raised questions about the possibility of degrading water quality in Big River Reservoir by diverting lower quality water from Flat River Reservoir. This possibility, along with the other adverse impacts of the diversion, ruled out Alternative 1.

Alternative 4 represented the most efficient plan of the four water supply alternatives studied. It also caused less adverse environmental and social impacts than the other alternatives. It was thus chosen for further evaluation as the water supply alternative to be included in the analysis of detailed multipurpose plans.

For more detailed descriptions and information on the water supply alternatives formulated in preliminary planning, see Appendix B, "Plan Formulation."

FLOOD DAMAGE REDUCTION

Management Measures

Potential measures for flood damage reduction can be divided into regulatory measures and corrective measures. Regulatory measures do not reduce or eliminate the threat of flooding, but rather regulate the use and development of the flood plains, lessening the potential for flood damage and loss of life. Corrective measures are designed to modify the

natural flood regime to protect individual structures or entire areas from flooding.

Regulatory measures include the National Flood Insurance Program, which provides flood insurance to property owners in flood prone areas, provided that State and local governments restrict future development in the affected areas. Flood plain regulations, such as zoning controls and building codes, could restrict new floodway area uses to help prevent increases in flood heights. Land use programs can restrict the amount and type of development in the flood plain. Other regulatory measures include urban renewal, which can allow flood prone areas to be rebuilt to withstand flooding; tax incentives to landowners, to encourage the preservation of open space in the flood plain; public open space acquisition, which can insure that flood plains remain open and available for public use.

Corrective measures include land treatment, an effective tool in controlling streambank erosion in areas where land use patterns are changing from agricultural to residential or other urban types. Reservoirs can store floodwaters temporarily to reduce flood peaks and then release them slowly. Walls and dikes of concrete or earthen construction can be used to confine floodflows to the channel or floodway. Hurricane barriers protect low-lying, heavily developed areas from storm-induced tidal surges. Stream modifications can increase the hydraulic efficiency and flood carrying capacity of waterways by such methods as widening and deepening channels, eliminating abrupt turns and oxbows, removing dams, and diverting floodflows. Floodproofing and relocation protect individual buildings and their contents by modifying or moving the structure.

In addition to regulatory and corrective measures, a No Action program was considered. Such a program would entail no Federal participation, assuming that all communities would control growth in their flood plains to meet the requirements of the National Flood Insurance Program.

A more detailed description of possible flood damage prevention measures is given in "Attachment 1" of this report.

Analysis of Plans Considered in Preliminary Planning

The regulatory and corrective measures discussed above, as well as the No Action plan, were evaluated on their own merits, and those not considered feasible or implementable, or those measures socially or environmentally unacceptable, were eliminated from further consideration.

Initial Screening. Land treatment measures in the area near Big River were retained as a possible adjunct to development of a reservoir there. Throughout the rest of the basin, erosion and sedimentation problems did not warrant land treatment measures.

Reservoirs were investigated throughout the basin, with only the Big River Reservoir project having the potential for substantial benefits. Modification of Scituate Reservoir was rejected as too costly for the additional flood control storage provided. Reservoir management programs, on the other hand, were reserved for further evaluation at Scituate and Flat River reservoirs.

Hurricane barriers to alleviate tidal flooding were considered, and rejected, at the mouth of the Pawtuxet and at the entrance to Pawtuxet Cove. The proposals would be too costly and environmentally harmful.

Several types of stream improvements were considered. Removal of dams was rejected, as all of the proposals were either impractical or environmentally unsound. Channel modifications were dropped, as they would not solve major problems, and were impractical to deal with minor problems in the basin. Intrabasin diversion schemes were investigated but none were justified. An interbasin diversion seemed viable for the West Warwick/Cranston area of the mainstem, and it was retained for further consideration.

Floodproofing and relocation was found to warrant further evaluation throughout the basin, as were all regulatory measures and the No Action plan.

Advanced Screening. Measures retained after the initial screening were further analyzed to determine their effectiveness. A nonstructural program was analyzed first due to public interest. Structural and future action programs were also analyzed.

The nonstructural plan utilized flood proofing as a major element, and involved the application of evaluation criteria to determine when and where it could be effectively applied. Such criteria as depth of design floodwaters, type of building construction, and esthetics of proposed measures were applied to the analysis. Costs of flood proofing were developed for both 100-year and Standard Project Flood (SPF). Benefits were likewise calculated, with B/C ratios of .10 and .04 for 100-year and SPF conditions, respectively, showing the economic infeasibility of floodproofing alone as a solution to the basin's flood problems. This measure was retained to be used in combination with others.

Structural flood control programs considered at this stage included two wall and dike systems and two possible diversion projects.

The wall and dike protection plans entailed 12 local protection projects in three communities, but were found to be economically unjustified. However, the analysis showed that local projects at Warwick and Elmwood Avenues warranted further study.

Diversions were considered for the Natick Dam and Pontiac Dam on the mainstem. Both proposals were developed for a number of different

designs, but only the Natick Diversion, with a rock tunnel, could be economically justified.

Future action programs of three types were found to be viable. Construction of Big River Reservoir, management of Scituate and Big River Reservoirs as a system, and erosion control measures at the Big River site were all plans that could be implemented by local interests.

Nonstructural flood proofing, although economically infeasible as an independent measure, was retained for consideration in conjunction with the Natick Diversion and the Elmwood Avenue and Warwick Avenue local protection projects. Reservoir construction, reservoir management and land treatment measures were retained as future action measures, and No Action and regulatory programs were retained for consideration as supplements to specific corrective measures.

Assessment and Evaluation of Detailed Plans. Ten detailed plans were formulated to address the basin's flood problems with a wide range of possible solutions.

Four plans (Plans A, B, C and G) included the Natick Diversion, at two different tunnel diameters. Three of these plans also included local protection projects at Warwick Avenue and/or Elmwood Avenue. All of the plans developed high annual benefits, but all were dropped due to lack of public acceptance, arising from public concerns over environmental impacts in Greenwich Bay from the diversion.

Plan D involved the Warwick and Elmwood Avenue local protection projects, alone, deleting the Natick Diversion. Cost sharing for this plan was not acceptable to local sponsors, so it was dropped.

Plan E involved provision of flood control storage of the proposed water supply reservoir on the Big River. The reservoir would be built by non-Federal interests under this plan. This plan had limited effectiveness in reducing overall damages, and was dropped due to the large residual losses expected.

Plan F was the No Action program, and did not effectively meet the planning objectives due to the large residual losses expected. It was thus dropped.

Plans H and I included Big River Reservoir, as a Federally constructed multipurpose project, and local protection for downstream areas. Plan I, including Warwick Avenue Local Protection and the Norwood Land Bank, was the more efficient of the two, and was retained.

Plan J was the nonstructural plan, involving flood proofing, relocation and regulatory measures. It proved to be extremely expensive and was economically unjustified.

Recommended Plan. Plans H and I were the only plans to meet planning objectives and be economically, socially and environmentally acceptable. As noted above, Plan I was the more efficient plan, and was therefore the recommended plan. The Warwick Avenue Local Protection project was dropped since local support was lacking. The Norwood Land Bank, a major portion of the plan, would involve relocating residents of the Norwood area of Warwick, and developing the land as a park. This part of the plan has strong local support, and appears to be urgently needed. In light of the need for improvements in the area, the Norwood Land Bank is being studied for implementation under the Flood Control Act of 1948, Section 205, which provides continuing authority for small flood control projects. Implementation of the Norwood Land Bank would be greatly expedited under the 205 authority as compared to authorization in conjunction with the rest of the comprehensive water resources plans developed in this study. The Norwood Land Bank proposal is thus not included in the description, impact assessment or evaluation of the detailed plans, nor are costs associated with it included under the multi-purpose plans developed under this study. For a complete description of flood control plan formulation, including a detailed description of the Norwood Land Bank, see "Attachment 1" of this report.

RECREATION

Management Measures

Potential recreational sites and activities to meet projected needs were analyzed for a region including that area within an hour's drive, about 40 miles, from the Big River site.

Existing use patterns and expected trends in recreation development, along with associated demographic factors, were analyzed to determine the appropriateness of recreational activities developed at the Big River site and other potential sites.

Projected development trends for the State showed that the Big River area would be likely to remain undeveloped and a desirable recreation area, throughout the study time frame. Its location close to the metropolitan area would increase its desirability. Enhancement of the natural attributes of the site was deemed a logical approach to recreational development of the local area.

Potential activities for development of the Big River site include swimming, camping and picnicking, wildlife and freshwater fisheries, boating and extensive outdoor recreation.

Swimming needs can be met by development of new areas at ponds and lakes as well as improvements to existing areas to enlarge or protect them from erosion and deterioration.

Camping and picnicking facilities, in short supply now, could be protected against encroachment, and new areas could be developed to meet increased demands.

Acquiring wetlands and upland wildlife management areas can enhance wildlife and freshwater fisheries recreation opportunities, including hunting and fishing. Providing access to these lands and to ponds and streams can also increase recreational opportunities.

Boating needs can be met by providing new launching ramps and allowing access to environmentally acceptable areas for boating.

Extensive outdoor recreation includes nature study, wilderness camping, informal picnicking and trail uses such as hiking, trail biking, and cross country skiing. These activities generally require fairly large amounts of land per person, and could be enhanced by the provision of limited public access to water supply watersheds, multiple use of trails, and scenic rivers legislation.

Plans of Others

The State of Rhode Island has identified major recreation needs of the State in its Plan for Recreation, Conservation and Open Space, June 1978. This plan is also Rhode Island's Statewide Comprehensive Outdoor Recreation Plan (SCORP). The plan makes recommendations to meet statewide recreation goals, and several of its recommendations are pertinent to this discussion:

. Provide fresh water swimming opportunities in the west and east metropolitan areas.

. Meet picnicking deficiencies in all regions.

. Provide accessible facilities for and promote use of multi-season recreational pursuits.

Development of Recreation Options

The recreation activities described above were combined into packages representing several levels of recreational development for the Big River site. Projected demands at the site are only a small portion of overall statewide demands, but have a large impact on local supply and demand. Thus, plans were developed to address primarily local needs.

The Big River site is presently being used informally for many recreational activities, but this condition could not be expected to continue should a reservoir be built, as the character of the site would change reducing the scope of some activities, enhancing others. Demand for recreational activities will increase at the site if a reservoir is built, as improved facilities would generate demand.

Three use level options have been developed for the Big River site, ranging from no admittance to a large scale facility.

Option I would prohibit all access to the site for recreation. Existing and future demands would have to be transferred from the site and absorbed by other recreation facilities in the area.

Option II would satisfy most future recreation needs by providing boating, fishing, hunting, swimming, hiking, horseback riding and picnicking. The Zeke's Bridge area, on Flat River Reservoir would be utilized for boating, fishing, picnicking and swimming. The Big River Reservoir recreation area would be developed for picnicking, shoreline fishing, and access to multipurpose trails. Carr Pond would be developed for picnicking and shoreline fishing. This option attempts to meet the "without condition" recreation needs, while minimizing water quality impacts due to recreation activities.

Option III includes all the activities in Option II and adds some activities and areas to provide a maximum recreation development plan for the reservoir. Additional facilities at Big River Reservoir (boating), Carr Pond (swimming, boating, trails), Phelps Pond (swimming, picnicking), and Hungry and Harkney Hills (camping) allow this plan to meet projected demands including those generated by reservoir development.

Analysis of Recreation Options

Impacts of the three recreation options were assessed with regard to the identified problems and needs. Major impacts would be felt in the local area.

Option I would create shortages for most recreational activities in the local area, creating negative impacts for some activities. Boating and hunting are the activities most negatively affected. As access to the site is prohibited, no on-site demands are met. Some environmental quality factors, such as water quality in the reservoir, and fish and wildlife habitat, would be positively impacted by this option.

Option II is essentially a mitigation plan for recreation, as it provides a level of recreation approximately equal to what would have existed without reservoir development. Thus, other local areas would avoid overcrowding under this option. However, shortages in capacity would be experienced in swimming and boating, due to the demand-generating effect of reservoir construction. Water quality effects are expected to be minimized, as intensive recreation activities are outside the watershed.

Option III can not only meet all projected local demands, including the effects of demand generation, but also provides some excess capacity to absorb statewide demands for some activities. According to past experience, Option III would not have any further water quality impacts than Option II, and would more fully exploit the recreational potential of the site.

Conclusions

The three plans considered for recreation represent three clear-cut management options for development of the Big River site. Option I, by prohibiting development, would not meet recreation needs for the area. Option II provides a level of development which would mitigate lost recreation opportunities due to reservoir development. Option III provides the maximum recreation development plan for the site, and has a positive impact on local recreation opportunities.

Option III, as the most efficient development, has been chosen as the recreation plan to be carried forward in the development of water resources management plans for the study area. More detailed information on the formulation of recreation plans is contained in Appendix H, "Recreation and Natural Resources."

ASSESSMENT AND EVALUATION OF DETAILED PLANS

In this section, detailed multipurpose plans are evaluated economically, socially and environmentally to determine the beneficial and adverse impacts of each. The degree of planning objective fulfillment of each is determined. Trade-off analyses are performed to analyze the comparative contributions of the alternative plans. Mitigation requirements, implementation responsibilities, and public views are also outlined for each plan as a further basis for comparison. The evaluation performed in this section provides the information leading to the designation of the NED, EQ and tentatively selected plans in the next section of the report.

Costs for the detailed multipurpose plans were estimated based on June 1981 price levels. For more information on the costs of each plan, including the time phasing of costs, see Appendix J, "Economics."

PLAN A

Plan Description

Water Supply. Study area demands of 127 mgd average day and 222 mgd maximum day in 2030 would be met by the implementation of a demand modification program, development of ground water in Burrillville, Glocester and Rehoboth, Massachusetts and by development of Big River Reservoir.

A comprehensive demand modification program, including water conservation education, distribution of water saving devices, institution of building code restrictions, and leak detection and repair programs, would reduce water supply needs by about 16 mgd on the average day and 28 mgd on the maximum day in 2030.

Ground water development in Burrillville and Glocester would serve Glocester and Foster, respectively. Foster's needs would be met by developing 1.0 mgd in Glocester in two phases, 0.5 mgd in 1990 and 0.5 mgd in 2010. Glocester would be served through the Pascoag Fire District, with 1.0 mgd in 1990 and 1.0 mgd in 2010.

The Bristol County Water Company, serving Barrington, Bristol and Warren, would meet its needs through development of ground water in Rehoboth, Massachusetts. Immediate development of 3.0 mgd would be necessary to meet present demands, with 2.0 mgd developed in 1995 and 1.0 mgd in 2015 to meet future demands through the end of the study time frame.

The primary element of this plan is the development of Big River Reservoir on the Big River in Coventry and West Greenwich. The reservoir would be located just upstream of the Flat River Reservoir and would provide 36 mgd safe yield. The dam site would be located where Harkney Hill Road crosses the Big River, with a maximum height of 70 feet and a total length of 2,240 feet. When filled to the design maximum water

supply pool elevation of 300.0 NGVD, the reservoir would inundate approximately 3,200 acres of forestland and streams. Flood control storage would increase the maximum pool level to 303.0 NGVD with the top of dam at 312.0 NGVD.

Along Route 95 in the Division Street area, construction of an impervious blanket to control seepage from the impoundment would be necessary. The impervious embankment fill would be 8,000 feet long with an 8-foot minimum thickness and would also entail construction of three dike sections for a total length of 2,400 feet, built to elevation 312.0 NGVD in certain areas adjacent to Route 95 where the natural hillside does not reach that elevation.

A chute-type spillway 400 feet in length would be located next to the north abutment of the dam and would discharge directly into Flat River Reservoir. Water treatment facilities with a 55 mgd capacity would be constructed on the northeast side of Hungry Hill, adjacent to Route 3. An 84-inch diameter tunnel would transport the treated water approximately 6.7 miles to a connection with the existing PWSB system in West Warwick.

The approximately 8,300 acres of state-owned lands surrounding the reservoir would be utilized for recreation and mitigation of natural and cultural resources impacts created by the project. Relocation of several primary roads would be required by project construction. Nooseneck Hill Road, Harkney Hill Road, and Hopkins Hill Road would be relocated under this plan to maintain continued use of through roads.

Water supply facilities proposed for Plan A are shown on Plate 8.

Flood Damage Reduction. Flood control storage equivalent to six inches of runoff from the watershed would be added to the water supply pool. Potential flood stage reductions would vary according to the type and location of the storm conditions, but would generally be larger on the South Branch and upper mainstem, and less on the lower mainstem. For a 100-year frequency event, flood control storage at Big River Reservoir would reduce flood stages by 1.6 feet at the Washington Gage, on the South Branch just below Flat River Reservoir; by 1.8 feet at the Natick Dam in West Warwick on the upper mainstem; by 1.2 feet at the Cranston USGS Gage on the middle mainstem; and by 0.8 feet at Warwick Avenue, on the lower mainstem. Reductions from a Standard Project Flood would be 2.4 feet at the Washington Gage; 2.7 feet at the Natick Dam; 2.3 feet at the Cranston USGS Gage; and 0.7 feet at Warwick Avenue. Average annual flood damages prevented would total $860,000 (June 1981 price levels).

Recreation. Future recreational needs of the study area would be met by development at the Big River site of facilities for boating, fishing, hiking, horseback riding, hunting, picnicking and swimming, as described under Option III. The Zeke's Bridge area, outside the watershed on Flat River Reservoir, would be developed for boating, fishing, swimming and picnicking. The Big River Reservoir recreation area would include picnicking, shoreline fishing, boating and access to a multi-use trail system. Carr Pond would be developed for swimming, picnicking, shoreline fishing, boating and trails, with additional swimming and picnicking

provided at Phelps Pond. Camping would be provided on Hungry and Harkney Hills and hunting areas would be accessible from the south side of the reservoir. These facilities could meet all projected recreation demands expected for the year 2020.

Impact Assessment

Plan A has both beneficial and adverse impacts associated with it. Adverse impacts include inundation of approximately 3,200 acres of stream/forest environment at the Big River Reservoir site, with accompanying losses to fish and wildlife habitat, cultural resources, and wetlands.

Downstream flows into Flat River Reservoir would be reduced by about 43 percent on the average. Ground water levels in the vicinity of the Big River Reservoir would increase by a small amount. The actual increase cannot be estimated with a high degree of accuracy, thus monitoring of ground water levels would be required after the reservoir is filled. Corrective action would then be taken if high ground water levels actually caused damage to existing development in the area. Approximately 30 million cubic yards of sand and gravel deposits in the impoundment area will be lost to possible mining development. Construction activities would cause temporary adverse effects on air quality and noise levels in the Big River project area. Relocation of about 440 residents located in the impoundment area would be necesssary.

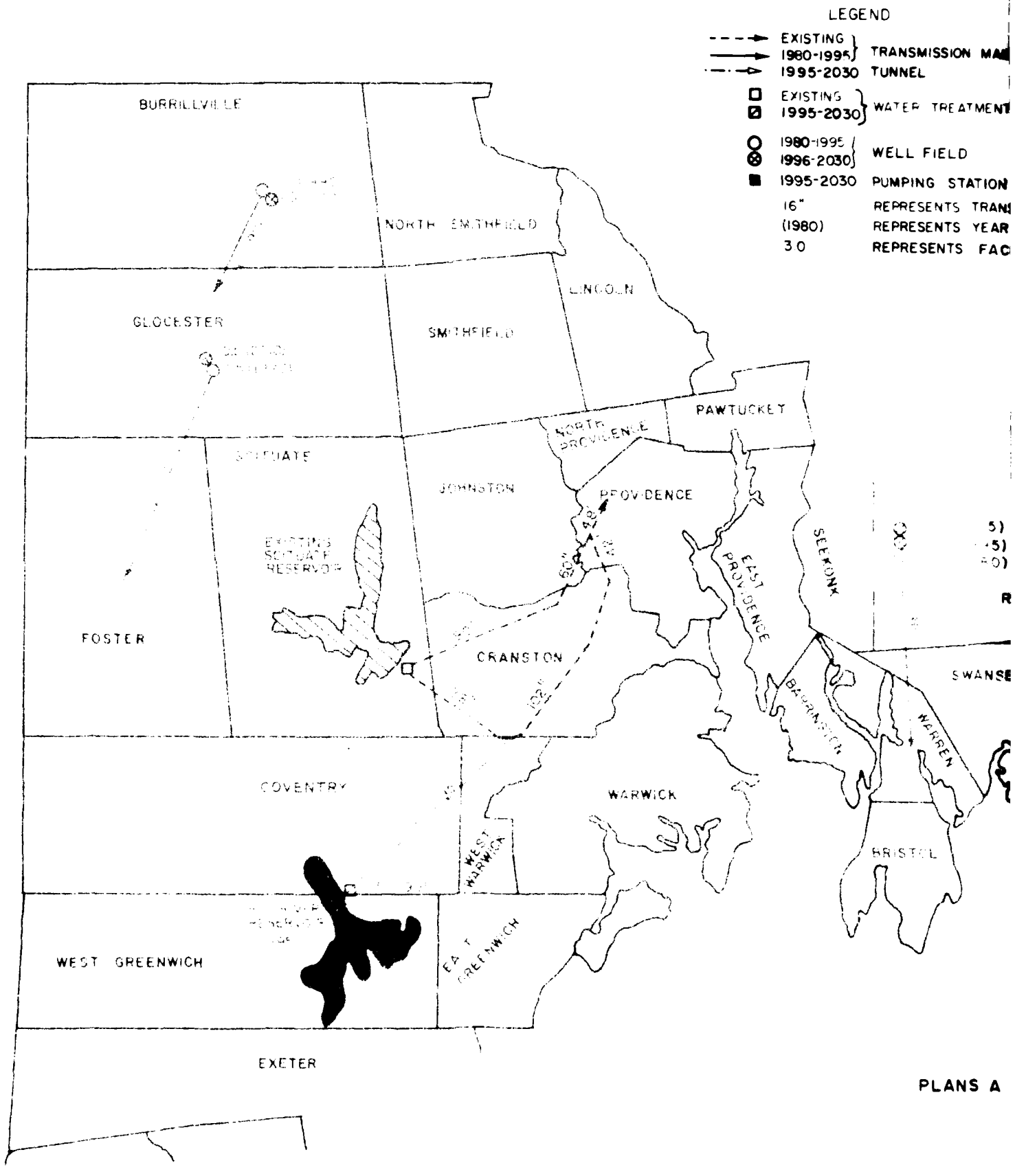
Subsurface easements would be necessary along the routes of transmission facilities, including the tunnel from Big River Reservoir. Transportation facilities in the vicinity of the proposed reservoir would be permanently affected. Several secondary roads in the impoundment area would be inundated and would thus be abandoned. These are Burnt Sawmill Road, Sweet Sawmill Road, Fish Hill Road, Phillips Road, and Division Street. Congdon Mill Road and the New London Turnpike, which pass through the impoundment area would also be abandoned in some section. The primary road relocations included in this plan would lessen the adverse effects of any road closings.

Reduced downstream flows would cause impacts to downstream riparian water users. However, the extent of such impacts cannot be determined without additional studies, which would be undertaken during advanced engineering and design stages.

The inclusion of flood control storage at Big River Reservoir would create some additional impacts beyond those associated with the water supply impoundment.

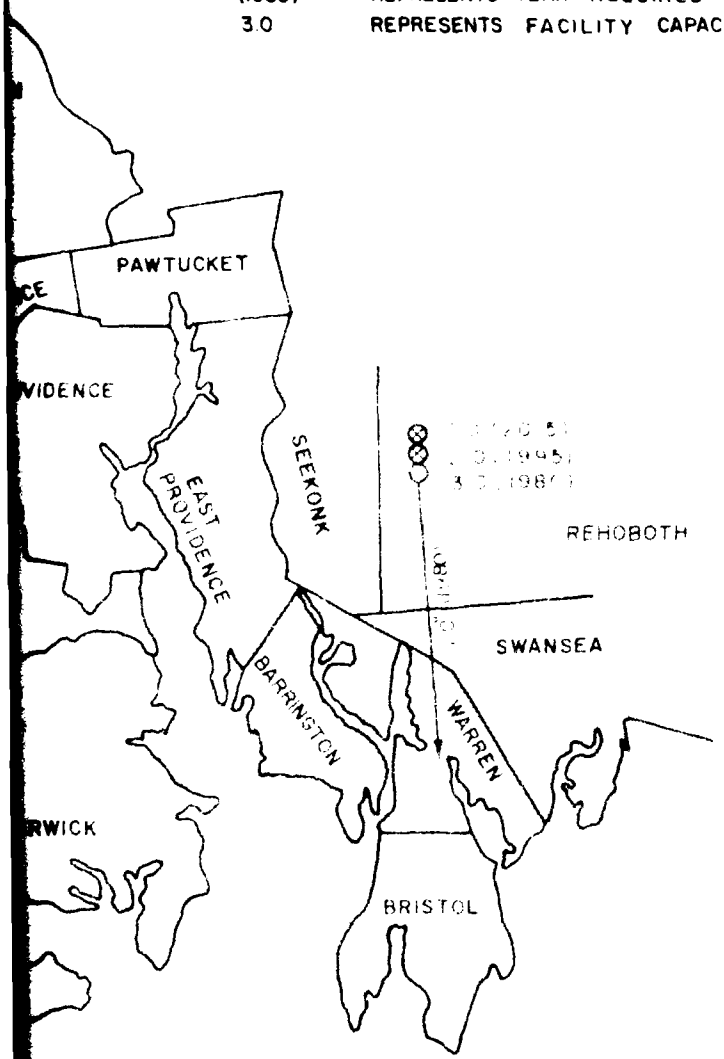
The recreational activities allowed under this plan would cause some impacts on the local area natural resources, such as damage to vegetation on trails, but proper management practices would minimize these impacts.

Minor environmental and social impacts would be created by ground water development in Burrillville and Glocester and in Rehoboth, Massachusetts. The construction of wells, pumping stations and transmission mains would create temporary noise and air quality impacts in the local areas of


LEGEND
EXISTING
1980-1995
1995-2030
TRANSMISSION MA
TUNNEL
EXISTING
1995-2030
WATER TREATMENT
1980-1995
1996-2030
WELL FIELD
1995-2030
PUMPING STATION
16"
REPRESENTS TRANS
(1980)
REPRESENTS YEAR
30
REPRESENTS FAC
BURRILLVILLE
NORTH SMITHFIELD
GLOCESTER
SMITHFIELD
LINCOLN
PAWTUCKET
NORTH PROVIDENCE
JOHNSTON
PROVIDENCE
EAST PROVIDENCE
SEEKONK
FOSTER
CRANSTON
BARRINGTON
WARREN
SWANSE
COVENTRY
WARWICK
WEST WARWICK
BRISTOL
WEST GREENWICH
EAST GREENWICH
EXETER
PLANS A

LEGEND

- EXISTING } TRANSMISSION MAIN
- 1980-1995 }
- 1995-2030 TUNNEL
- EXISTING } WATER TREATMENT PLANT
- 1995-2030 }
- 1980-1995 } WELL FIELD
- 1996-2030 }
- 1995-2030 PUMPING STATION
- 16" REPRESENTS TRANSMISSION MAIN SIZE
- (1980) REPRESENTS YEAR REQUIRED
- 3.0 REPRESENTS FACILITY CAPACITY IN MGD



PLANS A and B

PLATE 8

these activities. Temporary environmental damage may also occur in the immediate vicinity of ground water development, but this is also expected to be minor.

Beneficial impacts include provision of water supplies to meet projected 2030 water requirements for the study area, which would allow long term population and economic growth to occur as expected without constraints due to lack of water. Flood control storage at Big River Reservoir would provide protection to flood prone areas along the South Branch and mainstem Pawtuxet River. Recreation facilities at the reservoir site would satisfy most of the 2020 recreational needs for the study area.

Plan A has an estimated first cost of $59,081,000 and annual costs of $5,998,000. Annual benefits are estimated at $7,525,000, giving a benefit to cost ratio of 1.25. (Present worth values based on June 1981 price levels.)

Evaluation and Trade-Off Analysis

Plan A meets all of the planning objectives in an efficient manner, providing water supply, flood control and recreation benefits to the study area. It does not have a high level of acceptance, however, in the area of the proposed reservoir. It may become more acceptable with time, as water shortages worsen.

This plan would avoid the ill effects of such shortages by preventing them from occurring. It would enhance regional development, social well-being and the overall environmental quality of the study area. Aesthetic degradation due to water shortages would not occur.

The proposal for Bristol County to utilize ground water development to meet its needs would entail less environmental impacts in the Rehoboth, Massachusetts area than the combination of ground water and surface water development which would occur there under the without condition.

Environmental impacts would occur in the local area of the reservoir development. Adverse environmental effects such as loss of wetlands and forestland would be mitigated to the extent necessary to maintain overall habitat diversity.

Primary road relocations mitigate some social impacts due to the impoundment, but still may leave some negative impacts unmitigated that could be relieved if more extensive relocations were undertaken. These differences would only be felt in the local area.

The capability for implementation of the planned surface water development presently exists within the institutional structure of the study area. Inter-community cooperation would be required to implement the various elements in the plan, especially ground water development for Bristol County, where an interstate agreement would be necessary.

Mitigation Requirements

Mitigation of adverse environmental impacts would be required if the Big River Reservoir Project were Federally implemented. Mitigation measures would be intended to offset impacts on fish and wildlife and cultural resources. Among the techniques employed would be preservation and development of ideal wildlife habitat areas and intensive wildlife management practices to produce supplemental wildlife resources. Access control and development would ensure use of wildlife resources for hunting and other recreational purposes.

Several subimpoundment areas would be created by construction of suitable dikes and control facilities to retain water to Elev. 300.0 NGVD, creating wetlands and waterfowl habitat. In addition, several existing gravel mining areas would be graded and seeded to preserve and develop wildlife in those areas.

Mitigation of impacts on cultural resources would be required; the extent of impacts would be determined in advanced engineering and design studies. Mitigation techniques could include relocation of culturally important buildings, dike protection of archaeological sites, architectural recordings or archaeological recording measures.

Adverse impacts on downstream riparian water users due to reduced streamflows in the South Branch of the Pawtuxet would be mitigated. Downstream releases from Big River Reservoir and Flat River Reservoir would be coordinated so as to minimize adverse effects, and compensation would be made for losses suffered by downstream industries.

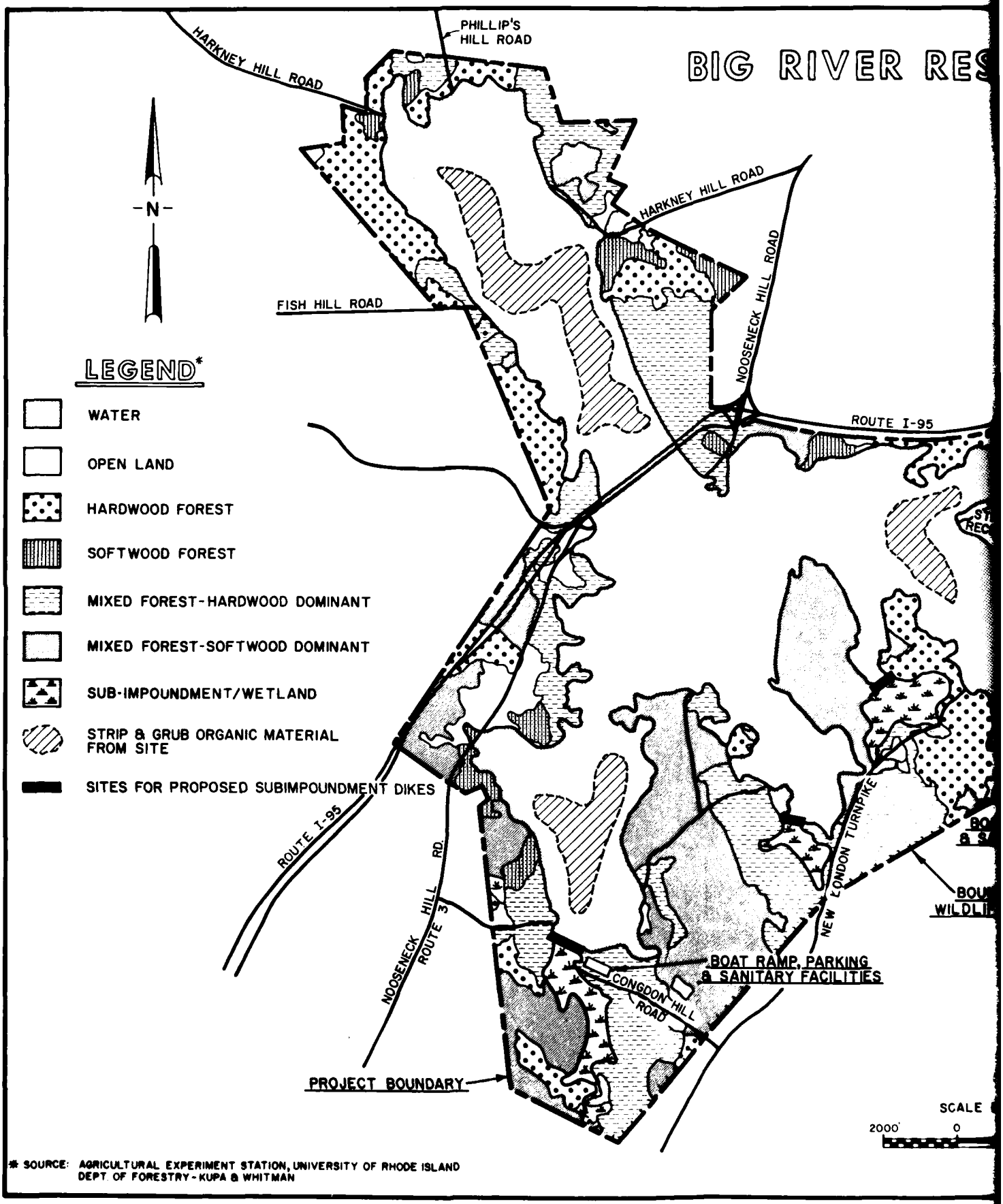
Fluctuation of Flat River Reservoir pool levels and associated impacts on waterfront property must also be mitigated, as would reduced waste assimilation capacity in the Pawtuxet River. However, all mitigation of downstream impacts such as these are not included in the mitigation costs cited. Advanced engineering studies will determine the costs of such efforts.

Proposed mitigation features for Plans A, B and C are shown on Plate 9.

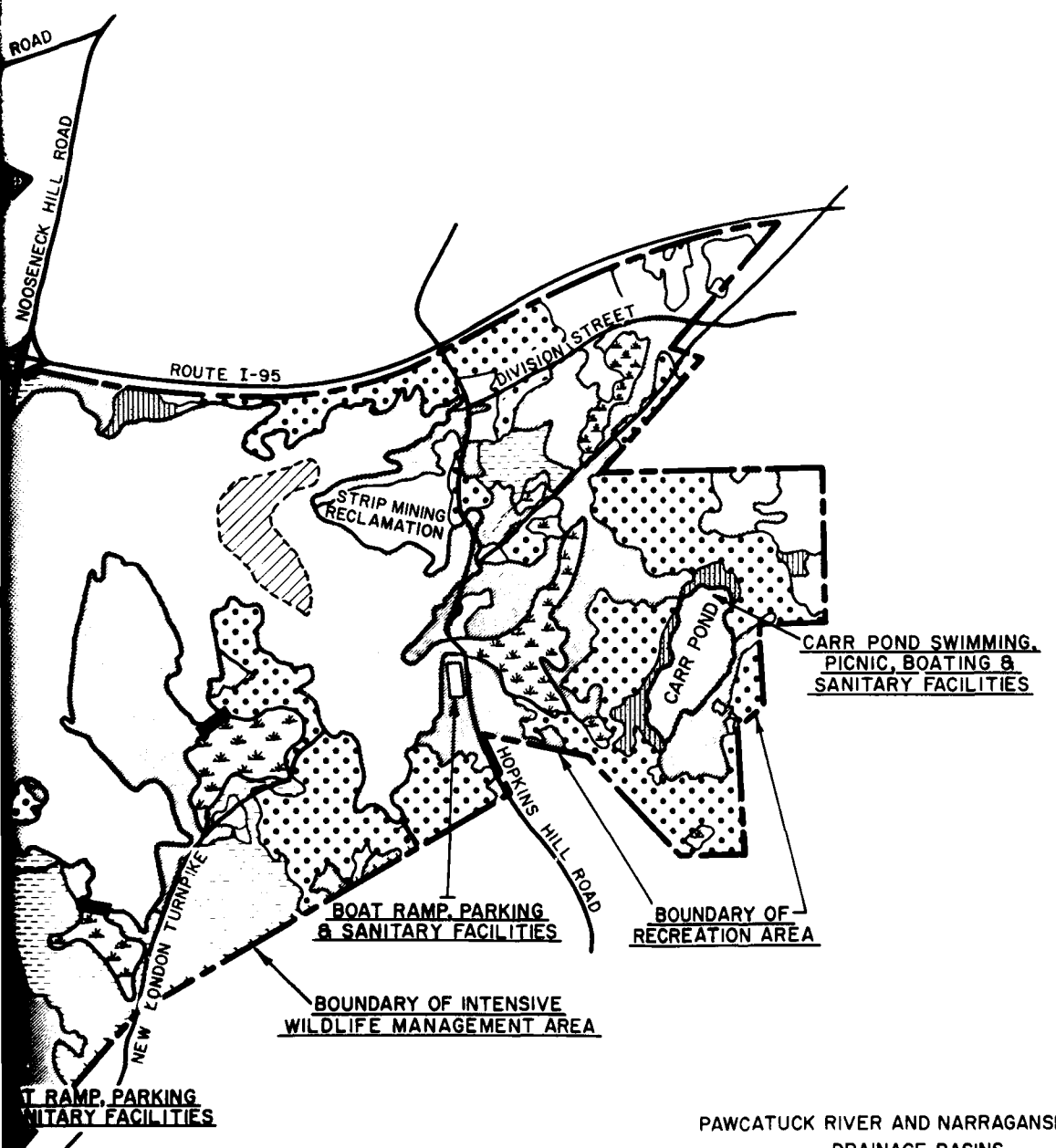
Implementation Responsibilities

Cost Allocation. All measures other than Big River Reservoir are single purpose water supply, thus all costs for these measures, including ground water development and demand modification, are allocated to water supply. Costs for the multi-purpose Big River Reservoir development are allocated to water supply, flood control, and recreation. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 2,120,000
Water Supply	56,808,000
Recreation	153,000
TOTAL	$59,081,000


BIG RIVER RES
HARKNEY HILL ROAD
PHILLIP'S HILL ROAD
HARKNEY HILL ROAD
NOOSENECK HILL ROAD
FISH HILL ROAD
ROUTE I-95
N
LEGEND*
WATER
OPEN LAND
HARDWOOD FOREST
SOFTWOOD FOREST
MIXED FOREST-HARDWOOD DOMINANT
MIXED FOREST-SOFTWOOD DOMINANT
SUB-IMPOUNDMENT/WETLAND
STRIP & GRUB ORGANIC MATERIAL FROM SITE
SITES FOR PROPOSED SUBIMPOUNDMENT DIKES
ROUTE I-95
NOOSENECK HILL RD.
ROUTE 3
NEW LONDON TURNPIKE
BOAT RAMP, PARKING & SANITARY FACILITIES
CONDON HILL ROAD
PROJECT BOUNDARY
SCALE
2000' 0
* SOURCE: AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF RHODE ISLAND
DEPT OF FORESTRY - KUPA & WHITMAN

G RIVER RESERVOIR AREA



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PROPOSED MITIGATION MEASURES - PLANS A, B & C

SCALE IN FEET
2000' 0 2000' 4000'

US Army Corps of Engineers
New England Division

PLATE 9

1 2

All costs are present worth values based on June 1981 price levels.

Cost Apportionment. The apportionment of costs between Federal and non-Federal interests reflects Federal water resources policies, which consider water supply storage the primary responsibility of non-Federal entities. However, a Federal interest may be found in projects which include other purposes. Thus, ground water and demand modification measures are the responsibility of non-Federal interests with no Federal cost sharing. Costs of the Big River Reservoir Project, as a multipurpose project, may be apportioned between Federal and non-Federal interests. Two cost sharing policies have been analyzed for this report: existing legislation, and the cost sharing policy proposed by former President Carter in June 1978. Cost apportionment under each policy is detailed below.

a. Existing Cost Sharing Legislation: Under existing legislation, construction costs allocated to flood control would be paid by the Federal Government. Lands, easements, rights-of-way, and relocations, and operation and maintenance costs would also be a Federal responsibility. Costs apportioned to water supply would be paid by the Federal Government, and repaid in full by the State of Rhode Island. Lands and damages would be repaid in the same manner as the construction costs. Operation and maintenance costs would be a non-Federal responsibility. Separable costs of recreation would be split, 50 percent paid by both Federal and non-Federal interests, except operations and maintenance costs associated with separable recreation, which would be paid by non-Federal interests.

b. President's Cost Sharing Policy: Under this policy, the State of Rhode Island would contribute five percent of construction costs allocable to flood control and recreation, and 10 percent of costs for water supply. In addition, the local sponsor (in this case assumed to be the State) would contribute 20 percent of flood control construction costs and 50 percent of separable recreation construction costs. Costs allocated to water supply would be repaid in full by the project sponsor. Lands and damages are shared in the same manner as construction costs for all project purposes. Operation and maintenance costs would be a Federal responsibility for flood control and non-separable recreation, and a non-Federal responsibility for water supply and separable recreation costs.

The Federal and non-Federal share of the construction costs for the two cost sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worth values.

	Existing Legislation	President's Policy
Federal	$ 2,224,000	$ 1,686,000
Non-Federal	43,939,000	44,477,000
Total Plan First Cost	$46,163,000	$46,163,000

Federal Responsibilities. Federal interests would be responsible for the Big River Reservoir development including the reservoir, recreation facilities and mitigation measures instituted as a result of the Big River development.

The Federal Government would design and prepare detailed plans, construct the project, and share in the cost of the proposed project as set forth above. Construction would be contingent on Congressional authorization and funding and on the receipt of the non-Federal share of the total project cost.

Federal responsibilities would also include any assistance necessary to non-Federal interests for implementation of a demand modification program.

The Federal Government would also provide assistance to localities participating in the National Flood Insurance Program, including technical assistance and establishment of flood plain management measures. These responsibilities are described more fully in "Attachment 1."

Non-Federal Responsibilities. Non-Federal responsibilities under this plan include construction of treatment facilities at Big River Reservoir and construction of the transmission main from the Big River treatment facilities to the connection with the existing PWSB system. Ground water development in Glocester, Burrillville and Rehoboth, Massachusetts would also be a non-Federal responsibility, as well as operations and maintenance of all facilities.

Public Views

Some elements of the public have voiced concern over the choice of Big River Reservoir to meet the study area's water supply needs, questioning the need for additional surface water development and fearing the potential environmental impacts of any such project. Overall, though, the Big River development appears to have a moderate to high level of acceptance, with State and local water resources agencies favorably disposed towards the project, and growing public awareness of the limits of existing supplies, brought about in part by water shortages during the summer of 1980 in some parts of the study area.

Other elements of this plan are not as controversial as the Big River development, and have not drawn as much public comment. Flood storage at the impoundment is favored should Big River Reservoir be built, and recreational development is generally favored, although some question its compatability with water supply storage. The proposed ground water development and demand modification program have not met with any objections.

PLAN B

Plan Description

Water Supply. This plan entails the same basic water supply development as Plan A, except that the Big River Reservoir would include a higher degree of development to enhance environmental quality as well as to minimize disruption of the social well-being of affected communities.

Demand modification and ground water development would be undertaken in the same manner as described under Plan A.

Development of Big River Reservoir would be the same as in Plan A, except that additional site preparation and relocations would be undertaken. Stripping and grubbing of selected inundated areas would be undertaken to improve water quality and enhance aquatic biota habitat. Congdon Mill Road and the New London Turnpike would be relocated under this plan to provide more continuity in the road network surrounding the reservoir site.

Regional water supply facilities proposed for Plan B are shown on Plate 8.

Flood Control. Under this plan, flood control storage at the Big River Reservoir would be the same as in Plan A.

Recreation. Recreation development would be the same as under Plan A.

Impact Assessment

Impacts associated with Plan B are similar to those of Plan A. Major differences in impacts of the plans occur to fish and wildlife, transportation facilities, and recreation opportunities.

Plan B includes additional environmental enhancement measures at the Big River site compared to those of Plan A. The various measures proposed under this plan would provide more positive environmental impacts at the Big River site. The quantity and quality of available fish and wildlife habitat would be increased under this plan by stripping and grubbing of selected inundated areas.

Transportation facilities in the local area would benefit from the additional road relocations proposed, allowing the maintenance of the existing road network, thus preventing overuse of roads not otherwise affected by reservoir construction. Recreation opportunities would be increased, as the additional road relocations would create improved access to the Big River site.

Plan B has an estimated first cost of $65,379,000 and annual costs of $6,531,000. Annual benefits are estimated at $7,525,000 giving a benefit to cost ratio of 1.15. (Present worth values based on June 1981 price levels.)

Other beneficial and adverse impacts of the two plans are virtually the same; for a description of these impacts see Plan A.

Evaluation and Trade-Off Analysis

Plan B would meet water supply, flood control, and recreation planning objectives in an efficient manner. This plan is generally similar to Plan A and thus has similar impacts and trade-offs made.

By preventing water shortages, this plan provides positive effects on regional development, social well-being and environmental quality in the study area, as noted in Plan A.

Environmental impacts of ground water development for Bristol County are the same under this plan as under Plan A, and likewise compare favorably to the without condition.

Localized environmental effects of Big River Reservoir would be abated to a greater degree under this plan than under Plan A. The additional fish and wildlife enhancement techniques employed at the Big River site would provide for more positive impacts on fish and wildlife.

Relocation of additional secondary roads will have more positive effects on local transportation facilities and recreation opportunities than under Plan A.

The addition of the above-mentioned features in the Big River area make the reservoir development under this plan somewhat more costly than the other plans.

Institutional arrangements are incomplete under this plan to the same extent as indicated for Plan A.

Mitigation Requirements

For Plan B, mitigation measures would be identical to those of Plan A.

Implementation Responsibilities

Cost Allocation. As in Plan A, all measures except Big River Reservoir are single purpose water supply, and the reservoir is multi-purpose. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 2,693,000
Water Supply	62,492,000
Recreation	194,000
TOTAL	$65,379,000

All costs are present worth values based on June 1981 price levels.

Cost Apportionment. Costs are apportioned in the same manner as for Plan A, to reflect the two cost sharing policies described in Plan A. The Federal and non-Federal share of the construction costs for the two cost sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worth values.

	Existing Legislation	President's Policy
Federal	$ 2,825,000	$ 2,141,000
Non-Federal	49,636,000	50,320,000
Total Plan First Cost	$52,461,000	$52,461,000

Federal Responsibilities. Federal responsibilities under this plan would be the same as under Plan A. Cost apportionment would be as described above.

Non-Federal Responsibilities. Responsibilities of State and local agencies and interests would be similar to those required under Plan A. Cost sharing would be as described above.

Public Views

Public opinion regarding this plan is essentially the same as that towards Plan A, as the differences between the two plans are not in the overall scope of the facilities developed. The relocation of additional roads, and the environmental enhancement measures included in this plan would be likely to draw favorable local public opinion.

PLAN C

Plan Description

Water Supply. This plan is similar to Plan A, except that it provides a more regional system for the study area. Ground water development to serve Bristol County would not be as intensive as in Plan A. Facilities to deliver water from the Providence water system would be required to meet future demands of the Bristol County Water Company system. Facilities developed under this plan are shown on Plate 10.

Development of ground water to serve Foster and Glocester would be the same as under Plan A, as would the demand modification efforts undertaken for this plan.

Ground water development would be undertaken in Rehoboth, Massachusetts to meet present needs of Bristol County until the time when water from the Big River Reservoir system becomes available. An immediate development of 3.0 mgd would be required to supplement existing supplies to meet average and maximum day demands through 1995.

Development of Big River Reservoir would be similar to that proposed in Plan A, except that treatment facilities of 60 mgd capacity would be built. Mitigation measures would be the same as in Plan A. However, some additional features aside from those required would be included as in Plan B. The road relocations included in Plan B would also be a part of Plan C. However, stripping and grubbing of inundated areas would not be included in Plan C.

The Bristol County Water Company system would receive water from the Providence water system through a pipeline originating in Cranston. The transmission main would be approximately 12.4 miles in length, crossing the Providence River and Warren River before terminating at the existing distribution system in Warren. A booster pumping station of 4.0 mgd capacity would be built in Barrington at the site of the existing Nayatt Road water treatment facilities. The pipeline and pumping station would be built in 1995 along with the Big River Reservoir development.

Flood Control. Flood control storage under this plan would be the same as in Plan A.

Recreation. Recreation facilities development would be the same as under Plan A.

Impact Assessment

Impacts occurring under Plan C are similar in many ways to those associated with Plan A. Ground water development for Foster and Glocester would impact those areas to the same extent as in Plan A. Development of a reservoir at the Big River site would have similar impacts to those described for Plan A, except that less social impacts would occur due to the additional road relocations included under Plan C.

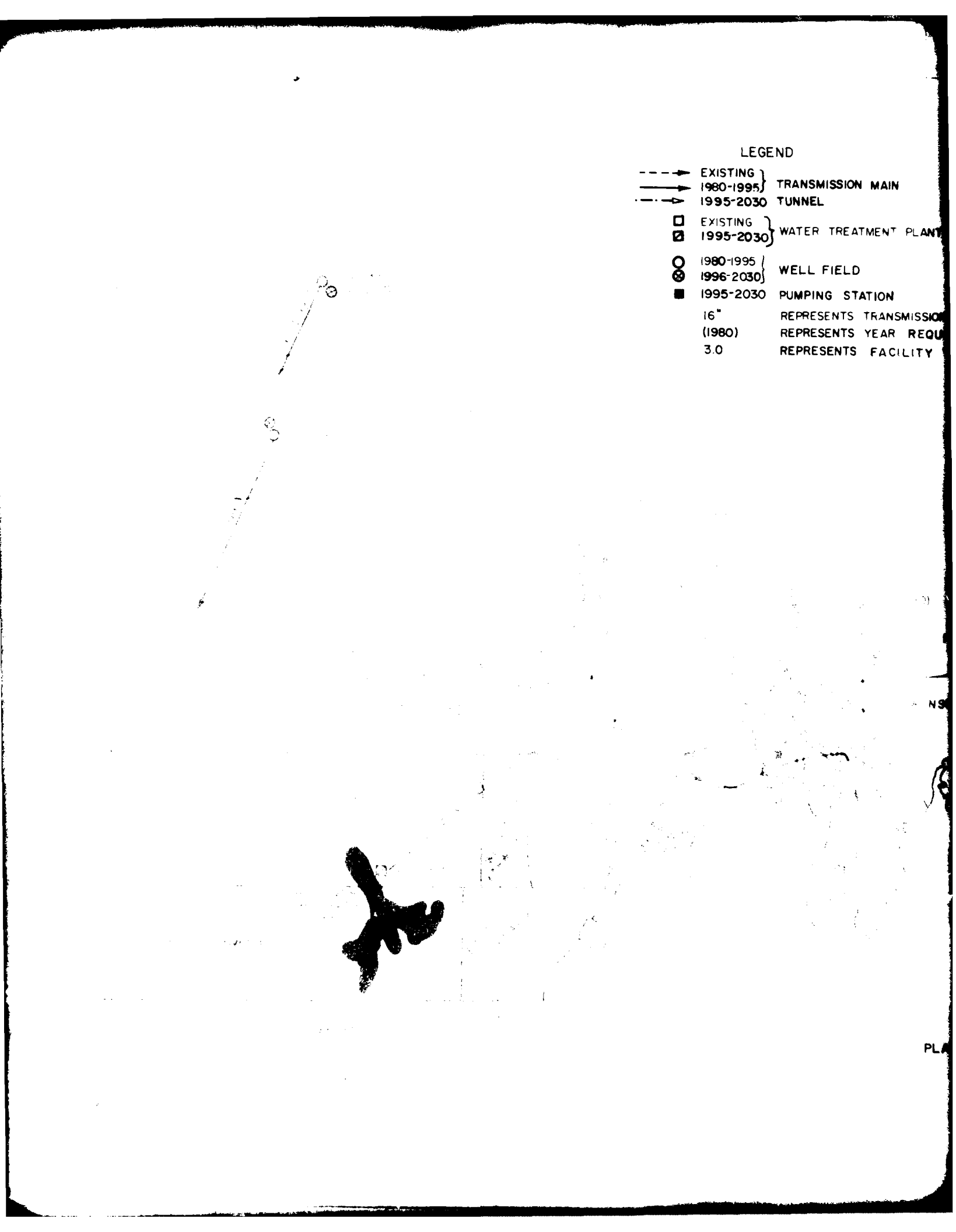
Differences in impacts would occur in the Bristol County development, to noise, air quality, and natural resources. Less intensive ground water development in Rehoboth, Massachusetts would cause less construction related noise and air quality degradation than caused by the staged development in Plans A and B.

Construction of the Providence-Bristol County connector pipeline would cause some impacts on noise and air quality along the pipeline route. These impacts would not occur under Plans A and B. However, noise and air quality impacts would be temporary, and evidence only during construction activities.

The Providence-Bristol County connector would also create impacts on existing marine biota in upper Narragansett Bay due to the excavation required to place the pipeline just beneath the surface of the bay floor. These disruptions would occur in the area between Conimicut Point in Warwick and Nayatt Point in Barrington. Following construction, the benthic organisms would become re-established in the area.

Plan C has an estimated first cost of $63,541,000, and annual costs of $6,455,000. Annual benefits are estimated at $7,525,000 giving a benefit to cost ratio of 1.17. (Present worth values based on June 1981 price levels.)

Other beneficial and adverse impacts of Plan C are the same as for Plan A; for a description of these impacts see Plan A.


LEGEND
EXISTING
1980-1995
TRANSMISSION MAIN
1995-2030 TUNNEL
EXISTING
1995-2030
WATER TREATMENT PLANT
1980-1995
1996-2030
WELL FIELD
1995-2030 PUMPING STATION
16" REPRESENTS TRANSMISSION
(1980) REPRESENTS YEAR REQU
3.0 REPRESENTS FACILITY

LEGEND

- EXISTING } TRANSMISSION MAIN
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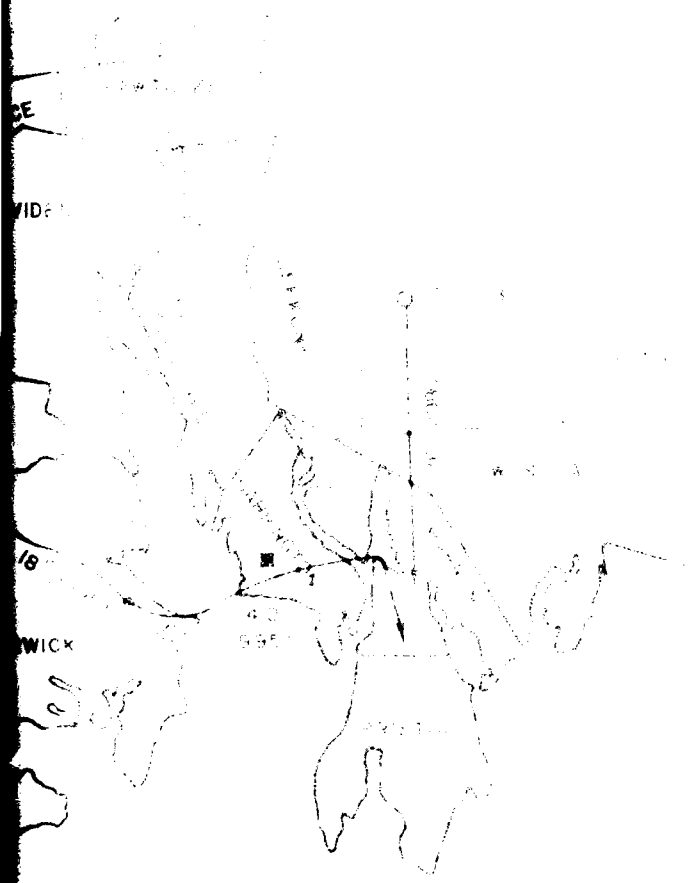
- EXISTING } WATER TREATMENT PLANT
- 1995-2030 }
- 1980-1995 } WELL FIELD
- 1996-2030 }
- 1995-2030 PUMPING STATION
- 16" REPRESENTS TRANSMISSION MAIN SIZE
- (1980) REPRESENTS YEAR REQUIRED
- 3.0 REPRESENTS FACILITY CAPACITY IN MGD



PLAN C

Evaluation and Trade-Off Analysis

Plan C would meet all study objectives in an efficient manner. This plan incorporates elements similar to Plan A, except in the Bristol County area. Regional development, social well-being, and environmental quality of the study area would be enhanced by the plan in the same ways as the other plans. However, greater adverse environmental impacts are created by the regional water supply elements of this plan than under the other plans. These impacts are fairly localized in the area of the connector between Providence and Bristol County.

Impacts associated with ground water development for Bristol County are less severe under this plan than under Plans A or B or the without condition, all of which entail greater development in the Rehoboth area than this plan.

This plan is more costly than Plan A, but less costly than Plan B. Additional ground water development in Rehoboth appears less expensive than the Providence connector proposed under this plan. However, institutional arrangements are much more complete for the Providence connector. Existing agreements between Providence and Bristol County have authorized construction of the pipeline, whereas no arrangements have been made for transmission of any amount of ground water from Rehoboth to Bristol County. Provision of ground water would require passage of legislation in Massachusetts, which could be largely dependent upon the expressed wishes of Rehoboth and nearby communities regarding their own use of the available resources. The likelihood of such authorization is greater if the amount of ground water requested is kept to a minimum, as proposed in this plan.

Mitigation Requirements

Mitigation requirements under this plan would be the same as under Plans A and B.

Implementation Responsibilities

Cost Allocation. As in Plans A and B, all measures except Big River Reservoir are single purpose water supply, and the reservoir is multipurpose. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 2,156,000
Water Supply	61,230,000
Recreation	155,000
TOTAL	$63,541,000

All costs are present worth values based on June 1981 price levels.

Cost Apportionment. Costs are apportioned in the same manner as for Plan A, to reflect the two cost sharing policies described in Plan A. The Federal and non-Federal share of the construction costs for the two cost

sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worth values.

	Existing Legislation	President's Policy
Federal	$ 2,261,000	$ 1,714,000
Non-Federal	48,362,000	48,909,000
Total Plan First Cost	$50,623,000	$50,623,000

Federal Responsibilities. Federal responsibilities under this plan would be the same as under Plan A. Cost apportionment would be as described above.

Non-Federal Responsibilities. Responsibilities of State and local agencies and interests would be similar to those required under Plan A, and also include construction of the Bristol County connector and the associated pumping station in Barrington. Cost apportionment would be as described above.

Public Views

Public views on this plan are much the same as those regarding Plan A. The only differences between the plans are in elements that are relatively uncontroversial, on which public views are not known.

COMPARISON OF DETAILED PLANS

In this section, the plans evaluated in the previous section are compared, and the NED and EQ plans are chosen. The recommended plan is also determined based on the best mix of elements of the detailed plans.

COMPARISON OF DETAILED PLANS

The three plans describe in detail possible ways of meeting the area's pressing water resource needs. All three plans do contain several common elements within the framework of the combination of the single purpose water supply, flood control and recreation alternatives.

A demand modification program was included in all plans, as it was shown to be both environmentally beneficial and economically sound as a water supply management measure. Ground water development for Foster and Glocester was likewise included in all plans as the most feasible alternative to meet those towns' needs. All plans contained surface water development at Big River Reservoir as the most practical way to provide the necessary water supply for the overall study area.

Differences between the plans are significant in several areas, especially between the proposal for Plan C and the other two plans. Impacts of the plans are similar in many ways, but also illustrate the different mixes of the elements in the plans.

The Big River Reservoir development would produce similar localized impacts for all three plans. The impoundment would alter the local environment by inundating 16.9 miles of streams, several small ponds and approximately 3,000 acres of wildlife habitat, of which around 570 acres are wetlands. The existing forest/stream/open land ecosystem would be converted to a large open water lake environment. Adverse impacts would result on the existing fish and wildlife resources as a result of the changed environment, but mitigation measures proposed for all three plans would offset losses and reduce impacts associated with the creation of the reservoir. The stripping and grubbing of selected inundated areas proposed under Plan B would further enhance water quality and fish and wildife habitat in the reservoir area.

Plan C would cause disruptions to marine life in a part of Narragansett Bay. However, Plans A and B would provide for more ground water development in Rehoboth, Massachusetts, creating more impacts there than would be caused by Plan C. The significance of impacts of additional ground water withdrawal under Plans A and B is not known, but some additional lowering of ground water levels would probably occur and could have significant effects on surface water flows in the area.

All three plans have moderate acceptability, with State agency support for the Big River development. All of the plans can meet the planning objectives efficiently and effectively, and are relatively adaptable to alternative futures. Plan C is the most implementable plan,

as necessary actions are more complete, and interstate agreements may be more likely under that plan's proposals. However, only a small part of the necessary actions and investments have been completed for any of the plans. Plan C is less reversible than Plans A or B, but none of the plans has a high degree of reversibility, due to the structural measures involved in all of the plans.

RATIONALE FOR DESIGNATION OF THE NED PLAN

An NED plan addresses the planning objectives in the way which maximizes net economic benefits. National Economic Development is optimized by the plan that is most economicallly efficient, as shown by the benefit to cost ratio, and which has the optimum scale of development. The NED Plan includes all measures with net positive economic benefits.

Plan A has been selected as the NED plan based on a B/C ratio of 1.25, as compared to the B/C ratios of Plans B and C of 1.15 and 1.17, respectively. Plan A includes the most efficient development of water resources to meet the study needs, as shown by the measures included in this plan. Demand modification to reduce demands is much more economical than development of new sources of supply. Ground water development for Foster and Glocester is cheaper than extending the Providence system to meet their needs. Likewise, ground water development for Bristol County is the most economical alternative to meet that area's needs. The Big River Reservoir development has been scaled to achieve maximum economic benefit, and only essential mitigation measures have been included. In addition to being economically efficient, this plan is also responsive to other evaluation criteria, such as acceptability, effectiveness and stability.

RATIONALE FOR DESIGNATION OF THE EQ PLAN

An EQ plan addresses the planning objectives in a way which emphasizes aesthetic, ecological and cultural contributions. Beneficial environmental quality contributions are made by preserving, maintaining, restoring or enhancing the significant cultural and natural environmental attributes of the study area.

Plan B has been selected as the EQ plan for the study area. This plan contains those elements that are EQ maximizing, while still meeting all the study planning objectives.

Plan B incorporates demand modification as a measure to reduce future water supply development needs. Beneficial environmental effects also occur from reduced wastewater flows to be treated. Individual subsurface disposal systems would also benefit from decreased consumption. Less environmental damage would be likely to result from malfunctions and overloading of these systems if demands were reduced.

Ground water development for Foster, Glocester and Bristol County is the most environmentally sound method of supplying these areas, as construction of long pipelines would not be necessary.

At the Big River Reservoir development, environmental enhancement measures in addition to those included in either Plans A or C would be undertaken to more completely offset fish and wildlife habitat losses caused by creation of the reservoir. Additional roads relocated under this plan would allow better access to the management area, and would minimize social disruptions in the local area.

RATIONALE FOR RECOMMENDED PLAN

The recommended plan is designed to be the best possible mix of measures to meet the planning objectives and respond to the goals of NED and EQ. Trade-offs are made in cases where NED and EQ measures are not compatible, and thus the recommended plan is developed to respond to the needs of the study area, while reflecting public desires and legal, institutional, environmental, social and economic constraints applicable to any proposals.

Plan C is the recommended plan for the study area. This plan is not the most efficient economically, nor is it the best plan environmentally, but existing institutional arrangements and constraints have been taken into account in this plan, resulting in the most implementable alternative among the detailed plans.

Several measures included in this plan are common to both the NED and EQ plans, as they were considered best from both points of view. Any such measures were included if also considered the most implementable alternative.

Ground water development for Foster and Glocester was included in both the NED and EQ plans and is also a part of the recommended plan. Water demand modification provides both environmental benefits and positive economic factors by deferring the need for additional supplies, treatment capacity and wastewater treatment facilities until later.

The recommended plan includes Big River Reservoir with the required mitigation and road relocations as indicated in the NED Plan (Plan A). It also includes the additional road relocations included in Plan B, but does not include stripping and grubbing in the inundated area. The expense of this additional environmental enhancement measure was not felt to be justified by the additional benefits gained.

The major difference between the recommended plan and the other two plans is in the proposal for a pipeline connecting Bristol County with the Providence system, which also includes reduced ground water development in Rehoboth, Massachusetts. This proposal is more costly than the more extensive ground water development in the other two plans, but the pipeline across Narragansett Bay does not require any interstate

cooperative agreements. Implementation authority already exists for pipeline connecting the Providence Water Supply Board system with that of the Bristol County Water Company. The lesser amount of ground water developed under this plan is more likely to obtain approval from Massachusetts, as a surplus would remain to accommodate any possible future needs of Rehoboth and nearby communities.

PROPOSED PROJECT FOR FEDERAL IMPLEMENTATION

Implementation of the Recommended Plan would require the combined efforts of Federal, State and local interests to develop various components of the plan. Development of ground water required to meet the immediate needs of Bristol County and long term needs of Foster and Glocester would be undertaken by local water supply agencies. Implementation of demand modification measures would be undertaken at the State or local level, using public or private organizations and voluntary efforts by residential users.

The multipurpose Big River Reservoir would be eligible for Federal implementation under present law. However, Federal involvement would be limited to construction of the reservoir and dam, outlet works, spillway, raw water conduit to the treatment plant, dike sections, recreational facilities, and cultural and natural resources mitigation. Other elements of this project, including treatment and transmission facilities, would be built by non-Federal interests. Complete detailed descriptions of the components of the proposed project for Federal implementation are presented in Appendix G, "Design and Cost Estimates" and Appendix H, "Recreation and Natural Resources." Project first costs and annual costs are summarized in Table 7.

Each of the project purposes - flood control, water supply, and recreation - have been evaluated to determine the economic justification of the proposed project. Project costs are allocated between the purposes to assure equal sharing in the savings from multiple-purpose development. Costs were allocated using the Separable Costs - Remaining Benefits (SCRB) method, as detailed in Appendix G, "Design and Cost Estimates."

All of the approximately 8,300 acres considered for implementation of the proposed Federal project are publicly owned by the State of Rhode Island through its Water Resources Board. These lands were originally purchased for the purpose of developing the Big River for water supply storage, including lands for watershed management and water quality control.

TABLE 7

SUMMARY OF FIRST COSTS AND ANNUAL COSTS

PROPOSED PROJECT FOR FEDERAL IMPLEMENTATION

PROJECT FIRST COSTS
(June 1981 Price Levels)

BIG RIVER RESERVOIR	$20,761,000
RECREATION	671,000
MITIGATION	1,940,000
CONTINGENCIES	4,675,000
ENGINEERING AND DESIGN	3,367,000
SUPERVISION AND ADMINISTRATION	2,244,000
REAL ESTATE COSTS	37,561,000
TOTAL PROJECT FIRST COST	$71,219,000
INTEREST DURING CONSTRUCTION	10,505,000
TOTAL INVESTMENT	$81,724,000

ANNUAL COSTS

INTEREST AND AMORTIZATION	$6,032,000
OPERATION AND MAINTENANCE	451,000
MAJOR REPLACEMENTS	1,000
TOTAL ANNUAL COSTS	$6,484,000

The proposed multipurpose Big River Reservoir would inundate an area of 3,240 acres at the maximum water supply pool elevation of 300.0 NGVD, and 3,400 acres at maximum flood control storage elevation 303.0 NGVD. The approximately 5,000 acres remaining would be utilized to provide 1) development of flood control storage, 2) development of recreation facilities, 3) measures for mitigation of cultural and natural resources impacts, 4) watershed management and water quality control, and 5) development of water treatment and related facilities.

Details of real estate requirements and costs are presented in Appendix G, "Design and Cost Estimates." Details of proposed recreation facilities and measures for natural resources mitigation are presented in Appendix H, "Recreation and Natural Resources."

Economics of the Proposed Project

The tangible economic justification of the proposed project for Federal implementation was determined by comparing the equivalent average annual costs (interest, amortization, operation and maintenance and major replacement costs) with the estimated equivalent average annual benefits expected to accrue over the economic life of the project. An interest rate of 7-3/8 percent was used to obtain comparable equivalent average annual costs and benefits which were estimated at June 1981 price levels. A complete discussion of the economic evaluation of all alternative water resources plans is presented in Appendix J, "Economics."

Estimated Project Costs. The total project first cost is estimated to be $71,219,000 and includes the cost of construction, lands and relocations, recreational facilities, and mitigation requirements for cultural and natural resources. The cost breakdown of the proposed multiple-purpose project and for alternative single- and dual-purpose projects is shown in Table 1 in Appendix G, "Design and Cost Estimates." Cost allocation for the proposed multipurpose project is summarized in Table 8.

Operation and maintenance costs of $451,000 per year were estimated on the basis of experience with other projects. Interest during construction was estimated for a four-year construction period by applying an interest rate of 7-3/8 percent for 2 years. Annual costs were computed on the basis of a 100-year project life with major replacement of equipment based on a useful life of 30 years.

Estimated Annual Benefits. Benefits derived from the proposed project for Federal implementation include average annual damages prevented by flood control storage at Big River Reservoir, water supply benefits and recreation benefits. Average annual benefits resulting from flood control storage are estimated at $860,000 in reduced flood damages to the communities of Coventry, West Warwick, Cranston, and Warwick. Water supply benefits were estimated on the basis of a single-purpose water supply project at the Big River site and amount to $6,321,000 annually. Recreation benefits were determined based on a comparison of

annual attendance for recreational activities at the site with and without the Big River project. The average annual benefits resulting from the project's recreational facilities are estimated to be $66,000, and are presented in detail in Appendix H, "Recreation and Natural Resources."

Benefits for water supply and flood control are described in detail in Appendix J, "Economics."

Economic Justification. The comparison of average annual benefits and average annual costs results in a benefit to cost ratio of 1.12 for the entire multiple-purpose project as shown in the summary presented in Table 8. Benefit to cost ratios for each of the project purposes are 1.40, 1.09, and 1.12 for the flood control, water supply and recreation components respectively. Details of the cost allocations and economic justification are more fully presented in Appendix G, "Design and Cost Estimates."

TABLE 8

SUMMARY OF ALLOCATION OF COSTS
(In $1,000 at June 1981 Price Levels)

MULTIPLE PURPOSE PROJECT

	FLOOD CONTROL	WATER SUPPLY	RECREATION	TOTAL
Project Cost	6,277	64,491	451	71,219
Interest During Construction	926	9,512	67	10,505
Investment	7,203	74,003	518	81,724
Annual Charges:				
Interest & Amortization	532	5,461	39	6,032
Operation & Maintenance	84	347	20	451
Major Replacement	0	1	0	1
Total	616	5,809	59	6,484
Annual Benefits:				
Flood Control	860			860
Water Supply		6,321		6,321
Recreation			66	66
Total	860	6,321	66	7,247
B/C Ratio	1.40	1.09	1.12	1.12

Division of Responsibilities

Legislative and administrative policies have established the basis for Federal and non-Federal sharing of responsibilities in the construction, operation and maintenance of Federal water resources projects. Cost apportionment under both existing cost sharing legislation and the President's cost sharing policy are explained for the Big River Reservoir development under the Implementation Responsibilities section in the Assessment and Evaluation of Detailed Plans. Other Federal and non-Federal responsibilities are also detailed in that section, for the detailed plans. Other responsibilities relating specifically to the proposed project for Federal implementation are given below.

Federal Responsibilities. The Federal Government, in addition to its responsibilities regarding design, construction and cost sharing in the project, would direct the operation of the flood control element of the project. The Corps of Engineers would set procedures by which local authorities would operate the project's flood control element, under Corps of Engineers direction. Radio communications equipment would be installed to facilitate Corps direction of flood control activities. Monitoring and data collection equipment would be installed throughout the watershed to aid in regulating flows. Operation and maintenance of flood control elements are normally a Federal responsibility, so reimbursement would be made to the operating non-Federal agency, by the Federal Government.

Joint-use recreation facilities operation and maintenance costs would be similarly reimbursed to the operating non-Federal agency by the Federal Government.

It is anticipated that agreements would be made to provide coordination of regulation activities at Scituate Reservoir and Flat River Reservoir in an effort to minimize flood damages in the Pawtuxet River Basin.

Non-Federal Responsibilities. Cost sharing, construction of treatment and transmission facilities, and operations and maintenance of the water supply and recreation portions of the project would be undertaken by non-Federal interests as described in the detailed plans. In addition, flood control operations and maintenance would be undertaken as described above, with Federal reimbursement of those costs.

Cost apportionment between Federal and non-Federal interests for the proposed project for Federal implementation is shown in Table 9.

TABLE 9

COST APPORTIONMENT
(In $1,000 at June 1981 Price Levels)

PROJECT FIRST COSTS

Existing Cost Sharing Legislation

	Federal	Non-Federal	*	Total
Flood Control	6,277	-	-	6,277
Water Supply	-	27,076	37,415	64,491
Recreation	305	-	146	451
Total Project First Cost	6,582	27,076	37,561	71,219

President's Cost Sharing Policy

	Federal	State	Non-Federal	*	Total
Flood Control	4,708	314	-	1,255	6,277
Water Supply	-	6,449	21,882	36,160	64,491
Recreation	282	23	-	146	451
Total Project First Cost	4,990	6,786	21,882	37,561	71,219

*Allocated fair market value of State-owned lands.

ANNUAL CHARGES
(Same for both policies)

	Interest & Amortization	Operation & Maintenance	Major Replacements	Total
Federal				
Flood Control	532	84 *	-	616
Water Supply	-	-	-	-
Recreation	26	2 *	-	28
Total Federal	558	86	0	644
Non-Federal				
Flood Control	-	-	-	0
Water Supply	5,461	347	1	5,809
Recreation	13	18	-	31
	5,474	365	1	5,840

*Estimated Operations and Maintenance cost for on-site flood control activities ($59,000) and joint-use recreation facilities ($2,000) would be assumed by non-Federal interests and reimbursed by the Federal Government.

CONCLUSIONS

The Division Engineer of the New England Division, Corps of Engineers has reviewed and evaluated, in light of the overall public interest, the information contained in the Environmental Impact Statement and other documents concerning water resource needs in the Providence, Rhode Island metropolitan area. The views of other agencies, organizations and individuals on the environmental and other impacts of the selected plan were also considered. In addition the Division Engineer or his representative has inspected the project area and participated in meetings with local officials, representatives of other agencies and organizations and other concerned members of the public.

In accordance with the Principles and Standards for water resources investigations a wide array of measures were evaluated. Table 10, Summary Comparison of Alternative Plans, is an overall general analysis relative to the selected plan, Plan C. It presents the determining factors that underlie each final alternative plan by displaying the significant beneficial and adverse impacts. This table is utilized for trade-off analysis and evaluation in the final decision making process.

AD-A107 148 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
BIG RIVER RESERVOIR PROJECT. PAWCATUCK RIVER AND NARRAGANSETT B--ETC(U)
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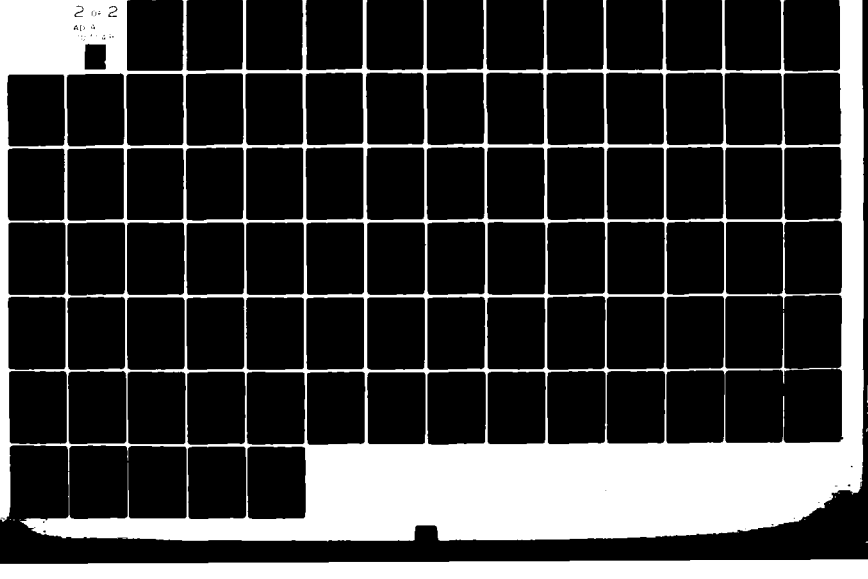

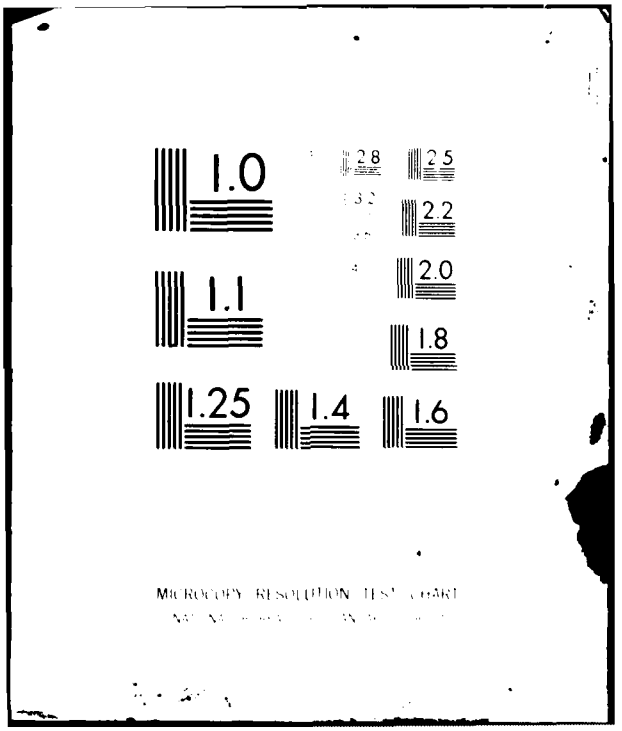
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1.25
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MICROCOPY RESOLUTION TEST CHART

TABLE 10

SUMMARY COMPARISON OF ALT

	WITHOUT CONDITION	PLAN A
A. Plan Description	No action taken to augment existing sources except by Bristol County - additional supplies obtained from new surface and groundwater sources in Rehoboth, Mass. Flood losses continue throughout basin, as no action taken to reduce damages. Recreational demands increase, no major new water related facilities developed in study area.	Big River Reservoir - 55 mgd trea recreation facilities. Groundwater development in Burril Rehoboth, Mass. Implementation of comprehensive m tion program.
B. Impact Assessment		
NED Objective:	N/A	Project Benefits Annual Charges B/C
EQ Objective:	a) Inundation of about 300 acres of stream/forest environment at site of Rocky Run Reservoir in Rehoboth, Mass. b) Reduced flows in study area streams and lowering of pond levels occurs due to increased surface and groundwater withdrawals from existing supplies. c) Increased pumping of existing wells may lower groundwater tables and reduce quality of withdrawals. d) Surface water quality will generally be lowered due to overdrafting of existing sources, resulting in usage of less potable water and reduced waste assimilation capacity of streams. e) Aesthetics in study area adversely affected by restrictions in water usage throughout most of study area. f) Temporary noise and air pollution in area of new reservoir development.	a) Inundation of approximately 3, forest environment at the Big b) Downstream flows into Flat Riv by 43 percent. c) Groundwater levels in vicinity Reservoir will increase by an d) Approximately 30 million cubic gravel deposits lost to develo e) Downstream water quality adver reduction in flows from Big Ri f) Minor environmental disruption water development. g) 14 small private cemeteries, 1 16 archaeological sites affect development. h) Creation of subimpoundments w losses due to reservoir develo
SWB Account:	a) 8 buildings acquired and residents relocated. b) Continued development will increase downstream flood stages, damage potential. c) Community growth and cohesion restricted and disrupted, respectively - unaffected in Bristol County. d) Road relocation at proposed Rocky Run Reservoir. e) Public facilities and services curtailed as a result of water supply sources. f) Recreation facilities usage curtailed due to water shortages. g) Temporary noise increase during construction of Rocky Run site.	a) 110 buildings in inundated are approx. 440 residents necessar b) Some reduction in downstream f c) Enhanced community cohesion a study area due to continued d supplies and reduced flood th d) Harkney Hill Road, Hopkins Hil Hill Road all relocated. e) Public services and facilities study area by provision of dep supplies. f) Recreation facilities would be enhanced opportunities. g) Temporary increase in noise d
RD Account:	a) Increased employment opportunity for construction workers in Bristol County during construction. b) Restricted regional growth due to inadequate water supplies and lack of flood protection, except in Bristol County. c) Property values and tax revenues decrease, except in Bristol County, due to inadequate water supplies and lack of flood protection. d) Business and industrial activity restricted, except in Bristol County, due to inadequate water supplies and lack of flood protection.	a) Increased employment opportun workers during construction of b) Increased regional growth und water supplies and increased c) Property values and tax revenu adequate water supplies and re d) Business and industrial activi reduced flood damages, increa
C. Plan Evaluation		
1. Contributions to Planning Objectives	N/A	a) Meets water supply needs by d sources, demand modification. b) Reduces flood damages along B Minister Pawtuxet. c) Provides recreational opportu exceed study area needs. d) Includes mitigation of some d cultural resources impacts du mentation.
2. Net Affects	N/A	a) Positive economic effect on d increased water supply and r b) Negative environmental impact mitigated to some extent. c) Overall social well-being in study area.; some disruption d vicinity. d) Positive effect on regional d employment opportunities, in and industrial activity due supplies and reduced flood d

TABLE 10

COMPARISON OF ALTERNATIVE PLANS

PLAN A	PLAN B	PLAN C
voir - 55 mgd treatment, flood storage, bilities. elopment in Burrillville, Glocester and e. of comprehensive water demand modifica-	Big River Reservoir - 55 mgd treatment, flood storage, recreation facilities, additional environmental enhancement measures - road relocations, stripping and grubbing in certain locations, strip mine reclamation. Groundwater development in Burrillville, Glocester and Rehoboth, Mass. Implementation of comprehensive water demand modification program.	Big River Reservoir - 60 mgd treatment, flood storage, recreation facilities. Goundwater development in Burrillville, Glocester. Pipeline connecting BCWC system with Providence system, interim groundwater development in Rehoboth. Implementation of comprehensive water demand modification program.
t Benefits $7,525,000 Charges 5,998,000 B/C 1.25	Project Benefits $7,525,000 Annual Charges 6,531,000 B/C 1.15	Project Benefits $7,525,000 Annual Charges 6,455,000 B/C 1.17
approximately 3,200 acres of stream/ ment at the Big River site. ows into Flat River Reservoir reduced . levels in vicinity of Big River l increase by an undetermined amount. 30 million cubic yards of sand and ts lost to development. ter quality adversely affected by flows from Big River. mental disruption in areas of ground- ment. ate cemeteries, 12 historical sites, ical sites affected by reservoir ubimpoundments would reduce wetlands reservoir development.	a) Similar to Plan A-a), except stripping and grubbing would enhance fish and wildlife habitat. b) thru h) Same as Plan A-b) thru h).	a) thru h) Same as Plan A-a) thru h). i) Approximately 15 acres of permanent and temporary easements for construction of transmission facilities from Providence system to serve Bristol County.
in inundated area; relocation of sidents necessary. in downstream flooding potential. unity cohesion and growth potential in to continued dependable water reduced flood threat. Road, Hopkins Hill Road, Nooseneck relocated. es and facilities enhanced throughout provision of dependable water ilities would be increased with rtunities. ease in noise during construction.	a) thru c) Same as Plan A-a) thru c). d) Same as Plan A-d) with the addition of Congdon Mill Road and the New London Turnpike. e) thru g) Same as Plan A-e) thru g).	a) thru g) Same as Plan B-a) thru g).
loyment opportunity for construction construction of projects. onal growth made possible be adequate and increased flood protection. es and tax revenues increase due to supplies and reduced flood damages. industrial activity enhanced due to damages, increased water supplies.	a) thru d) Same as Plan A-a) thru d).	a) thru d) Same as Plan A-a) thru d).
pply needs by development of new d modification. damages along South Branch and et. tional opportunities to meet or es needs. tion of some fish and wildlife and ese impacts due to project imple-	a) thru c) Same as Plan A-a) thru c). d) Provides additional site preparation to reduce adverse environmental impacts due to project implementation.	a) thru d) Same as Plan A-a) thru d).
ic effect on study area due to supply and reduced flood damages. mental impacts in reservoir area, e extent. well-being is enhanced throughout e disruption in immediate reservoir on regional development; increased rtunities, tax revenues, business activity due to adequate water duced flood damages.	a) Same as Plan A-a). b) Less negative environmental impacts than in Plan A. c) Less disruption in reservoir vicinity due to more extensive road relocations than in Plan A. d) Same as Plan A-d).	a) Same as Plan A-a). b) Similar to Plan A-b), but some additional temporary negative impacts in areas of pipeline river crossings. c) and d) Same as Plan B-c) and d).

TABLE 10 (Co

C. Plan Evaluation (Continued)		
3. Plan Response to Associated Evaluation Criteria	N/A	
a) Acceptability by affected public.		a) Less acceptable.
b) Certainty of achieving planning objectives.		b) Positive.
c) Completeness of necessary actions and investments to assure plan attainment.		c) Complete.
d) Effectiveness of meeting planning objectives.		d) Effective.
e) Efficiency in responding to planning objectives.		e) Most efficient.
f) Geographic scope encompassed by plan.		f) Study area.
g) Reversibility		g) Low.
h) Stability to alternative futures.		h) High.
4. Rankings of Plans	N/A	(NED Pla
NED		1
EQ		2
SWB		2
RD		1
D. Implementation Responsibilities	N/A	
1. Federal Responsibilities		a) Existing Legislation: Big R all costs allocated to flood construction, operation and all joint costs allocated to of separable recreation cost costs paid up front (repaid interests). b) President's Cost Sharing Pol voir project, 75 percent of flood control, including la costs allocated to recreatio able recreation costs. All costs. Operation and mainte Federal responsibility for recreation. c) Other Responsibilities: Fe and build the Big River Rese the reservoir, recreation fa measures.
2. Non-Federal Responsibilities		a) Existing Legislation: Big R all costs allocated to water costs are repaid to Federal of separable recreation cost tenance costs allocated to separable recreation. b) President's Cost Sharing Pol 5 percent of construction co control and recreation, and water supply; the non-Federa tribute 20 percent of all co control, 50 percent of separ the remaining 90 percent of (repaid to Federal Governme maintenance costs are non-Fe supply and separable recreat c) Other Responsibilities: Non construct treatment facilitie Reservoir, the transmission treatment facilities to the in Burrillville, Glocester a Operations and maintenance c

TABLE 10 (Continued)

nable.	a) Most acceptable environmentally and socially.	a) Most acceptable.
	b) Positive.	b) Positive.
	c) Complete.	c) Complete.
	d) Effective.	d) Effective.
ient.	e) Least efficient.	e) Efficient.
.	f) Study area.	f) Study area.
	g) Low.	g) Low.
	h) High.	h) High.
(NED Plan)	(EQ Plan)	
1	3	2
2	1	3
2	1	1
1	1	1
gislation: Big River Reservoir project, allocated to flood control (incl. on, operation and maintenance, lands); costs allocated to recreation; 50 percent ble recreation costs. All water supply up front (repaid by non-Federal).	a) thru c) Same as Plan A-a) thru c).	a) thru c) Same as Plan A-a) thru c).
e Cost Sharing Policy: Big River Reser- t, 75 percent of all costs allocated to rol, including lands; 95 percent of joint ated to recreation; 45 percent of separ- ation costs. All costs include land eration and maintenance costs are a onsibility for flood control and joint .		
onsibilities: Federal interests design the Big River Reservoir project including oir, recreation facilities and mitigation		
gislation: Big River Reservoir project, allocated to water supply (construction repaid to Federal Government); 50 percent ble recreation costs; operations and main- nce costs allocated to water supply and recreation.	a) thru c) Same as Plan A-a) thru c).	a) and b) Same as Plan A-a) and b). c) Similar to Plan A-c), but also includes construction, operation and maintenance of connector to Bristol County system and associated pumping station.
e Cost Sharing Policy: State contributes of construction costs allocated to flood and recreation, and 10 percent of costs for dy; the non-Federal sponsor would con- percent of all costs allocated to flood 0 percent of separable recreation costs, ing 90 percent of water supply costs Federal Government); operation and e costs are non-Federally paid for water separable recreation.		
onsibilities: Non-Federal interests treatment facilities at Big River the transmission main from the Big River facilities to the FWSD system, wellfields ville, Gloucester and Rehoboth, Mass. and maintenance on all facilities.		

RECOMMENDED PLAN

The Recommended Plan for the study area consists of a comprehensive water resources management plan for flood damage reduction, municipal and industrial water supply and recreation. Flood damage reduction is limited to the Pawtuxet River Basin and centers on major damage areas along the mainstem in West Warwick, Warwick and Cranston. Damages would be reduced by the provision of floodwater storage in the proposed Big River Reservoir and by continued participation in the National Flood Insurance Program. Water supply needs of study area communities would be satisfied by implementation of a water conservation program focusing on reduction of future water demands by the phased development of groundwater and surface water resources having a combined safe yield of 42 million gallons per day (MGD). Recreational needs within the State of Rhode Island would be served in part by the provision of various recreational opportunities within the State-owned reservoir property in concert with the proposed development. The Recommended Plan, designated as Plan C earlier in the report, is shown on Plate 10.

Phased development of groundwater supplies would serve the needs of some of the less densely populated communities in the study area in addition to meeting the present and short-term demands of Bristol County communities. Construction of the proposed multiple-purpose Big River Reservoir would provide water supply storage to satisfy the needs of systems serving the city of Providence and other communities in the metropolitan area. Water and sludge treatment facilities having a design capacity of 60 MGD, an aqueduct consisting of an 84-inch diameter tunnel approximately 6.7 miles in length, and water transmission facilities consisting of about 12.4 miles of 18-inch pipeline to serve future needs of the Bristol County communities of Barrington, Bristol and Warren would also be constructed. The proposed reservoir and treatment facilities would be located on property acquired by the State of Rhode Island during the mid-1960's.

Not all elements of the Recommended Plan are eligible for implementation by the Federal government. The water conservation program, groundwater resources development, and water supply transmission and aqueduct facilities would be implemented by State or local authorities. Likewise, water and sludge treatment facilities would be the responsibility of State or local authorities. Only the multiple-purpose Big River Reservoir and dam, including a 90-inch diameter, 3200-feet long raw water aqueduct, associated recreation facilities and measures for mitigation of cultural and natural resources would be eligible for implementation by the Federal government under current Corps of Engineers authority. This project would be developed in greater detail during Advanced Engineering and Design Studies if authorized.

The Big River Reservoir would inundate an area of about 3400 acres (5.3 square miles) at spillway crest of 303.0 feet National Geodetic Vertical Datum (NGVD). The approximately 2240 feet long dam would be

constructed to an elevation of 312.0 feet NGVD and would have a maximum height of 70 feet above streambed. Total storage capacity provided by the reservoir would be 95,400 acre-feet consisting of 12,300 acre-feet of conservation storage, 73,600 acre-feet of water supply storage, and 9,500 acre-feet of flood control storage. A section of the impoundment, between Division Street and Interstate Route 95 extending easterly from Nooseneck Hill Road (Route 3) for approximately 8000 feet, would require construction of an impervious blanket to control seepage out of the reservoir. Operation of the proposed Big River Reservoir in combination with existing surface water supply facilities at Scituate Reservoir would provide a safe yield for water supply purposes of about 113 MGD, sufficient to meet projected demands of the study area through the year 2030.

The flood control element of the project would reduce flood stages, such as experienced in the July 1938 and March 1968 floods, by about 1.5 to 2.0 feet in the South Branch and upper mainstem of the Pawtuxet River. On the lower mainstem, in the vicinity of the Warwick Industrial Park, the reduction would be in the order of 0.5 foot.

Recreational opportunities for boating, camping, fishing, horseback-riding, hunting, picnicking, and swimming and mitigation measures for cultural and natural resources would be implemented within the State-owned reservoir property.

The estimated total first cost of the recommended multiple-purpose dam and reservoir which provides flood damage reduction, water supply and recreation is $71,219,000 with average annual charges of $6,484,000. Average annual flood damage reduction, water supply and recreation benefits are $7,247,000 resulting in a benefit-cost ratio of 1.12 to 1.

Estimated average annual operation, maintenance and major replacement costs of the recommended project are $452,000.

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

FINAL

ENVIRONMENTAL IMPACT STATEMENT

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

FINAL
ENVIRONMENTAL IMPACT STATEMENT

Feasibility Study of Big River Reservoir
West Greenwich, Rhode Island

The responsible lead agency is the U.S. Army Corps of Engineers, New England Division.
The responsible cooperating agency is the U.S. Fish and Wildlife Service.

Abstract: The proposed Big River Reservoir area is located in Coventry and West Greenwich, Rhode Island within the state-owned Big River Management Area. The proposed Big River dam would be located at the confluence of Big River and the Flat River Reservoir in Coventry, Rhode Island. It would inundate approximately 3240 acres in the 29.7 square mile Big River watershed. The Corps' study focused on the identification of water supply, flood damage, and recreation problems in the Big River study area, and the formulation of a recommended water resources development and management plan by analyzing the area's needs, concerns, and alternative solutions. Out of seven methods studied to satisfy the water supply needs in the study area, groundwater, demand modification (water conservation), and surface water development were determined as the most feasible alternatives. Through analysis of the intermediate study results, three basic plans were developed utilizing portions of these alternatives to provide for the projected water supply needs of the study area to the year 2030. Plan A consists of implementation of a demand modification program throughout the study area, development of groundwater sources in Glocester and Burrillville to serve Foster and Glocester, and in Rehoboth, MA to serve Bristol County, development of a multi-purpose Big River Reservoir, flood damage reduction measures, recreational development, and fish and wildlife mitigation. Plan B is similar to Plan A; however, under this plan additional site preparation and relocations would be undertaken. Plan C is also similar to Plan B except that it provides a more regional system for the study area, less intensive groundwater development for the Bristol County area and construction of facilities to deliver water from the Providence water system to meet future demands of the Bristol County Water Company system. Flood control and recreation potential were evaluated equally in the three plans. Plan C has been recommended based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

If you would like further information on this statement, please contact:

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U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254
Commercial Telephone:
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FTS Telephone: 839-7643

NOTE: Information, displays, maps etc. discussed in the Big River Main Report are incorporated by reference in the EIS.

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1.00 SUMMARY

1.01 Major Conclusions and Findings

The objective of this feasibility study is to arrive at a recommended water resources development and management plan for those communities within the Pawtuxet River basin, one of five major sub-basins comprising the entire Pawcatuck River and Narragansett Bay Study region, and also for those within the legislated service area of the Providence Water Supply Board. Review and analyses of the needs, alternative solutions and concerns of these areas have been the major efforts of the Corps towards the study objective. Big River was considered early in the study as the most significant study element (Figure 1). It is potentially the structural measure which would most adequately meet the projected needs.

Average water supply needs within the study area are estimated to increase from approximately 72 million gallons per day (mgd) in 1975 to almost 109 mgd in the year 2000 and about 142 mgd by the year 2030. Water deficits resulting from these demand projections would amount to approximately 18 mgd and 51 mgd by the year 2000 and 2030 respectively.

Maximum demands are estimated to increase from approximately 124 mgd in 1975 to 190 mgd in the year 2000 and almost 250 mgd by the year 2030. These demands reflect deficits of approximately 30 mgd and 90 mgd in existing systems projected for the years 2000 and 2030 respectively.

Broad categories of water resource technologies were investigated for the economic and technical potential to meet this need: seawater desalination, weather modification, iceberg transport, wastewater reuse, groundwater, water demand modification, and surface water development. A "Without Condition" (no action) projected scenario was reviewed. Groundwater, water demand modification, and surface water development were determined to be the most feasible of these technologies.

An evaluation of these potential technologies led to the development of intermediate alternatives for water supply and flood damage reduction measures (Plans A,B, and C). Applicable demand modification, available groundwater resources, and potential surface water development including Big River, Flat River, Wood River and Moosup River were studied in detail. Demand modification is predicted to relieve about 11 percent of the estimated 2030 municipal demand. Available groundwater reserves were estimated as able to provide about 9 mgd of additional water supplies. adequate surface water potential exists to satisfy the total predicted increase. Big River Reservoir would provide about 36 mgd and was chosen as more desirable than the other reservoir sites because of greater potential and environmental and institutional opposition to other sites. Through analysis of the intermediate study results, three basic plans were developed utilizing contributions of these measures to satisfy the projected water supply needs of the study area to the year 2030:

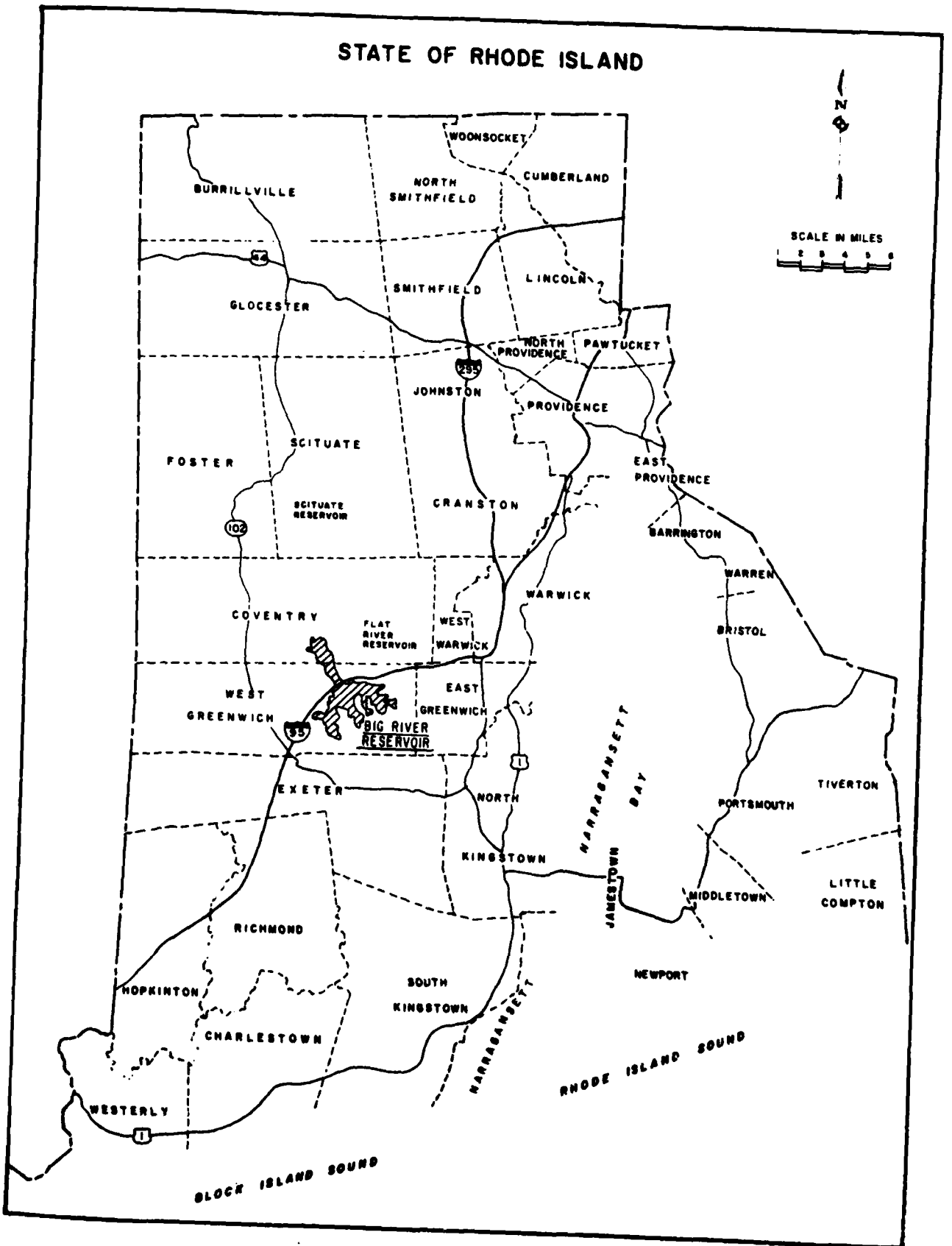
Plan (A) - NED Plan. Implementation of a demand modification program (water conservation) throughout the study area, development of groundwater sources in Glocester and Burrillville to serve Foster and Glocester, and in Rehoboth, MA to serve Bristol County, development of a multi-purpose Big River Reservoir, flood damage reduction measures, recreational development, and fish and wildlife mitigation.

Plan (B) - EQ Plan. Development of Big River Reservoir, demand modification, groundwater development, flood damage reduction measures, recreational development, additional site preparation and relocations, and fish and wildlife mitigation.

Plan (C) - Recommended Plan. Development of Big River Reservoir, a demand modification program, less intensive groundwater development for the Bristol County area, and construction of facilities to deliver water from the Providence water system to meet future demands of the Bristol County Water Company system, flood damage reduction measures, recreational development, and fish and wildlife mitigation measures and relocations as proposed for Plan B.

In accordance with the Water Resources Council's Principles and Standards and Corps Regulation ER 1105-2-200, these measures and plans accounted for contributions to National Economic Development (NED), Environmental Quality (EQ), Social Well Being (SWB) and Regional Development (RD) (Appendix B). Through analysis of this "System of Accounts", Plan C has been recommended based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

The Corps' proposed fish and wildlife mitigation plan presents those management measures considered to be feasible at this stage of study to offset losses due to the development of Big River Reservoir. This plan incorporates many of the recommendations provided to the Corps by the U.S. Fish and Wildlife Service, the Rhode Island Department of Environmental Management, and consultants' mitigation reports. These are structural and administrative conceptual measures that would be incorporated into construction and post-construction activities. They include construction of subimpoundments to create wetland habitat, intensive wildlife management on the reservoir watershed lands, and development of a cold-water fishery in Big River Reservoir. See Section 3.00 for further discussion of these recommendations. Should the project be authorized for advanced engineering and design studies, mitigation would be studied in detail to further define the viability of the recommended measures.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FOSTER
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CRANSTON
BARRINGTON
WARREN
WARWICK
COVENTRY
FLAT RIVER RESERVOIR
WEST WARWICK
BRISTOL
WEST GREENWICH
EAST GREENWICH
BIG RIVER RESERVOIR
EXETER
NORTH KINGSTOWN
NARRAGANSETT BAY
TIVERTON
PORTSMOUTH
LITTLE COMPTON
MIDDLETOWN
RICHMOND
NEWPORT
HOPKINTON
SOUTH KINGSTOWN
CHARLESTOWN
NARRAGANSETT
RHODE ISLAND SOUND
WESTERLY
BLOCK ISLAND SOUND

FIGURE 1

1.02 Areas of Controversy

Review of the sources and types of concerns within the area revealed areas of disagreement among several of the concerned agencies and interests. These issues of controversy, shown in Table 1 and detailed in Appendix C, "Public Participation" were given priority consideration during the Corps' study. The most significant controversies relate to the multiuse concept, needs for more water supplies, fish and wildlife mitigation, and fiscal and management issues.

1.03 Resolution of Significant and Controversial Issues

Although some issues are beyond the authority of the Corps to resolve, various studies were conducted to develop recommendations and answers for the more significant and controversial issues. Such studies and analyses included:

(1) an up-to-date analysis of the water supply needs of Rhode Island (Appendix A, "Problem Identification");

(2) special studies evaluating the potential of demand modification and groundwater resources available to the study area (Appendix A, "Public Participation" and Appendix B, "Plan Formulation");

(3) examination of multiuse potential of the proposed Big River Management Area and Reservoir (Appendix H, "Recreation and Natural Resources");

(4) special ecological studies to describe the natural resources, to recommend fish and wildlife mitigation measures, and to describe social values associated with the Big River project area (Appendix H, "Recreation and Natural Resources," and Appendix I, "Social and Cultural Resources");

(5) engineering studies to determine the technical and economic feasibility of the proposed Big River Project (Appendix D, "Hydrologic Analysis", Appendix E "Water Quality", Appendix F, "Geotechnical Investigations", and Appendix G, "Design and Cost Estimates."

Through analyses of these various studies, resource management alternatives which best address the problems of water supply, flood damage reduction, and recreation in the study area were derived. The selected plans were based on the following conclusions:

(1) the eventual need for additional water supplies is evident;

TABLE 1

PUBLIC INTEREST ISSUES - ANALYSIS OF CONTROVERSY

TYPES OF ISSUES/CONTROVERSY

PUBLIC INTEREST CATEGORIES	NEED FOR RESERVOIR ALTERNATIVE ASSESSMENT	FISCAL AND MANAGEMENT	ACCESS AND MULTI-USE OF RESERVOIR	ENVIRONMENTAL CONSIDERATIONS	ECONOMIC/TECHNICAL FEASIBILITY
FEDERAL AGENCIES					
U.S. Fish & Wildlife Service	Requests additional studies	NEC[1]	Major concern favors access for hunting and fishing	Major concern - Fish & Wildlife impacts & mitigation	NEC
STATE AGENCIES					
Office of State Planning	Some concern	Concern over lack of comprehensive State policy on water resources mgmt.-desires State ownership & mgmt.	Concern - question single-use concept	NEC	NEC
RI Water Resources Board	Expressed that need is already evident, stressed avoidance of further delays	Concern - favors State ownership	Advocate of multi-use with emphasis on prevalant constraints	NEC	NEC
Dept. Environmental Mgmt.	Concerned with the assessment of major increases in per capita consumption of water for the study years.	Supports the development of the Big River Reservoir as a future water supply	Supports multiple use of the reservoir and endorses recreation plan.	Major concern with minimum low flow release - desires additional projections of water needs in the study area. Favors implementation of a fish and wildlife mitigation plan.	Expressed that the economic feasibility of transmission line to Aquidneck Island be addressed. Also, the cost of runoff mitigation should be included in the BC Ratio
LOCAL GOVERNMENT					
Providence Water Supply Board	Consider need is evident for Big River & possibly additional sources	Desire that they construct and operate Big River	Disfavor multi-use of reservoir on the basis that it would conflict with water quality	NEC	NEC
Providence Planning and Urban Development	Consider that need is evident	Agree w/PWSB but wishes to expand authority & service area in Metropolitan Board	Major concern-disfavor the multi-use concept. Agrees with PWSB	NEC	NEC
Communities at Big River Site	Concern	Disfavors any future land acquisition. Concern over fiscal/mgmt. as related to town revenues.	Disfavor single-use concept. Impacts on local area residents.	Major concern-desire knowledge of extent of impacts to local community.	Concern-desires more evidence on economic/technical feasibility
INTEREST GROUPS					
Environmental	Requests additional studies	Desires studies of secondary costs & comprehensive water resource mgmt. policy	Disfavor single-use concept	Major concern-desire more detailed environmental studies	Concern with water quality and secondary economic impacts
Recreational	Desires further evidence of need	Concern related to access & multi-use	Major concern strongly disfavors single-use concept	Major concern losses to recreational opportunities	Concern - desires more evidence on economic/technical feasibility
PRIVATE CITIZENS	Desires further evidence of need	Concern - mostly who and how	Concern desires multi-use concept	Concern - basically desires more knowledge	Concern with feasibility

[1]No Expressed Concern.

(2) demand modification and greater groundwater development are practicable and desirable to help meet these needs. Big River Reservoir alone would not be sufficient to meet the projected needs without effective demand modification or adequate groundwater development or additional surface water supply development;

(3) Big River Reservoir is economically and technically feasible and preferable over development of other surface water sites;

(4) the Corps favors and supports multiuse of the reservoir and adjacent public lands. The recreation analysis indicates that studies conducted country-wide support recreational use of water supply reservoirs;

(5) analysis of the natural, cultural and economic resources of the proposed Big River project area has identified significant potential impacts which can be minimized and mitigated by appropriate watershed management and the multiuse concept; and,

(6) the need for reduction of flood damages in the developed areas of the Pawtuxet River Basin.

1.04 ENVIRONMENTAL REQUIREMENTS

Table 2 presents the relationship of the proposed project and study to relevant environmental requirements.

TABLE 2
RELATIONSHIP OF PROPOSED BIG RIVER RESERVOIR STUDY
TO RELEVANT ENVIRONMENTAL REQUIREMENTS

REQUIREMENT TITLE	OBJECTIVE OF REQUIREMENT	NATURE OF STUDY COMPLIANCE	REFERENCE
Fish and Wildlife Coordination Act	Requires coordination with U.S. FWS and State F & W agencies to obtain views and concerns on F & W in relation to potential project - authorized F & W mitigation	Coordination was developed - U.S F & WS planning aid letter considered. State concerns received informally. Mitigation plan being developed	Appendix H, Vol. 4
National Environmental Policy Act	Requires that environmental concerns receive equal consideration to other study elements, especially in alternative review and selection	Preparation of EIS to show how NEPA was utilized in study planning	This document (EIS)
National Historic Preservation Act	Requires investigation and consideration of archaeological and historical resources in project planning	Studies conducted to determine extent of resources and predict impact	Appendix I
Clean Water Act Section 404	Requires evaluation of effects of discharge on aquatic resources, especially wetlands, recreation, and water supply	Evaluation conducted and condition recommended to minimize relevent effects	404 Evaluation
Endangered Species Act	Established and requires consideration of endangered species list	Potential effect on endangered species or critical habitat thereof evaluated	Appendix H, Vols. 2 & 3
Executive Order (11990) Protection of Wetlands	Emphasizes protection of wetlands in any proposed development	Wetland values studied in proposed project mitigation proposed	Appendix H, Vols. 3 & 4
Water Resources Planning Act	Established Water Resource Council (WRC) and requires compliance with recommendation	Utilized WRC principles and standards during plan formulation	Appendix B
Rhode Island Law (46-14-1) Pollution or Misuse of Drinking Water Source Prohibited	Prohibits discharge of wastes or pollution in Rhode Island drinking water sources; specifically prohibits bathing and swimming	Recreation planning conforms to law	Appendix H, Volume 1

2.00 NEED FOR AND OBJECTIVES OF STUDY

2.01 Study Authority

On 29 March 1968, the Committee on Public Works of the United States Senate adopted a resolution requesting the Board of Engineers for Rivers and Harbors to study the advisability of improvements for flood control, navigation, water supply, water quality control, recreation, low-flow augmentation and other allied water uses within the Pawcatuck River and Narragansett Bay drainage basins (Appendix A, "Problem Identification"). The study area includes all of Rhode Island (except the south coastal section) a portion of southeastern Massachusetts, and the Pawcatuck River area in Connecticut.

This resolution promulgated the Pawcatuck-Narragansett Bay (PNB) study by the Corps of Engineers, New England Division in 1969, and, in 1978, Governor Garrahy of Rhode Island requested the Corps of Engineers to focus their ongoing PNB study toward a timely evaluation of the feasibility of Big River Reservoir.

Big River Reservoir has been proposed by the Rhode Island Water Resources Board as a primary measure to augment existing water supplies in view of predictions of water supply needs in Rhode Island.

Authorization for this study, along with those studies that indicate the advisability of the Big River site, are discussed further in the Main Report.

2.02 Planning Objectives

The primary objective of this study is to determine the feasibility of the proposed Big River Reservoir to serve as an element in an overall water resources development and management plan for the State of Rhode Island, and to arrive at a recommended plan consisting of acceptable measures which best satisfy the needs of the study area including flood control and recreation potential. The Main Report discusses further the planning objectives and formulation process.

2.03 Public Concerns

The most significant concerns elicited from the public participation program include the following:

(1) a comprehensive, realistic analysis of the need for Big River Reservoir and other potential sources in light of more up-to-date population and water demand predictions;

(2) appropriate consideration be given to alternatives, especially demand modification and groundwater development;

(3) development of a comprehensive water resources management plan that proposes a wise and conservative use of natural resources;

(4) consideration and study of the potential of Big River for multiple uses, i.e., recreation rather than the "single-use" (water supply only) policy that prevails now at most New England water supply systems, including that of the Providence Water Supply Board;

(5) analysis, consideration, and presentation of the environmental impacts, along with mitigation measures to offset losses to fish and wildlife resources associated with the development of Big River Reservoir; and,

(6) a thorough study of the technical and economic feasibility of the Big River site for a large reservoir, i.e., adequacy of watershed to fill and operate the reservoir, water quality in the reservoir, necessity for diversions, and adequate foundation (potential leak problem).

3.00 ALTERNATIVES

3.01 Alternatives Considered During The Planning Process

3.01.1 General

Alternative technologies reviewed by the Corps of Engineers' study for meeting the needs of water supply in the Providence metropolitan study area include: icebergs, wastewater re-use, weather modification, desalination, groundwater, water demand modification, and surface water. Each of these alternatives is discussed in more detail in Appendix B, "Plan Formulation." In the preliminary investigations each of these technologies was analyzed independently for generic potential to satisfy the study objectives.

Detailed investigations for flood damage reduction measures were carried out for the Pawtuxet River Basin, and have been presented in the interim report to the PNB study "Pawtuxet River Watershed - Flood Control Report." Flood control alternatives have been subsequently proposed and evaluated, and are presented in Appendix B, "Plan Formulation."

Three use level options for development of recreation facilities in the Big River Reservoir area are discussed in this section of the EIS and also in Appendix H, "Recreation and Natural Resources."

3.01.2 Iceberg Harvesting

Recent proposals have indicated that removal and transport of large icebergs from polar regions to areas of water needs is somewhat feasible. The technique, however, involves transportation and storage problems as yet unresolved and the feasibility has not yet been successfully demonstrated. Therefore, this alternative was not considered for further study.

3.01.3 Wastewater Re-use

Water treatment technology has recently made wastewater re-use a viable source of water for many uses as the level and cost of treatment is related to the intended use. Several industrial firms have found it to be economical for quenching, cooling and fire protection. Other applied uses include irrigation, underground water barrier and municipal water supplies. However, municipal water supplies require high quality water for use in the home; the level of treatment necessary to provide this quality of water has, to date, made wastewater re-use noncompetitive with other available methods of water supply in areas of adequate rainfall. An advantage to wastewater re-use is that poorly treated wastewater discharges and associated pollution would be eliminated. This method is the most environmentally acceptable method known, but is not considered economically acceptable within this study's criteria.

3.01.4 Weather Modification

Rhode Island has adequate rainfall to provide water for all its predicted needs. The problem is storage for safe yields in periods of low rainfall. Rain making techniques such as cloud seeding have shown promise in many areas of the country. However, dry periods would also be the most likely times where cloud seeding would be ineffectual because during dry periods, no clouds would be present to seed. This method, although of limited application in the western states for irrigation, shows little promise in New England. The potential environmental impacts of artificially releasing water in one area, and not in others, are not fully understood.

3.01.5 Desalination

Methods of desalination include distillation, crystallization, reverse osmosis, and ultrafiltration. A discussion of these methods is found in Appendix B, "Plan Formulation." Practically all plants in operation today use the distillation process; however, a few use the membrane and crystallization processes. Desalination shows the most promise as a future source of water supply in arid regions near oceans where operation can be in conjunction with a large power plant whose waste heat can be used as part of the heat source necessary for the distillation process. Major environmental problems associated with desalination include the disposal of brine wastes which have high salt content, organic and mineral contaminants, and the high energy requirements associated with the process.

3.01.6 Groundwater

Groundwater is often the most economical, and, if used prudently, one of the least environmentally damaging methods of water supply for residential, agricultural and industrial use. It is usually the least likely to require treatment and least expensive to develop on a small scale.

Groundwater is regarded as a desirable and reasonable source of water supply in Rhode Island. Unfortunately, available groundwater reserves are not sufficient to significantly offset predicted needs in the study area. Many of the existing aquifers in the study area, and also throughout the populated Northeast, have been polluted by improper waste disposal. Estimates indicate that about 13 mgd of good quality groundwater could presently be obtained in the study area (Appendix B, "Plan Formulation").

3.01.7 Water Demand Modification

There are five basic methods to control water demands in contemporary municipal water supply systems. They are: pricing policies, water saving devices, conservation education, restrictive use, and control of system losses. These methods can be used singly or collectively to reduce water use in a municipal system, or, more likely, to curb the ever increasing water use. The Corps study of the potential of demand modification in the Providence area indicates that implementation of a comprehensive program of water conservation utilizing education, water saving devices, building code restrictions, and leak repair comprise the most feasible plan for implementation in the study area. (Appendix B, "Plan Formulation"). This type of plan could reduce municipal water use by as much as 11 percent by the year 2030.

3.01.8 Surface Water

Surface water is the oldest and most widespread source of water for public and private uses in the world. Major cities are located along waterways and near lakes not only because of transportation opportunity, but also for an adequate water supply. Another major waterway use, as a repository for industrial and municipal wastes, has in most urban areas degraded water quality to such an extent that substantial chemical treatment is now necessary to render the water safe for human consumption.

In Rhode Island all of the rivers large enough to serve as a dependable water supply are polluted in varying degrees and utilized for a variety of industrial purposes. The Blackstone River, the largest in Rhode Island, is reported as being utilized more heavily for industrial purposes than any other river in the world (Encyclopedia Americana, 1976). The smaller tributaries generally provide good quality water, but small and undependable safe yields unless storage is provided.

In areas with topographic conditions that permit effective impounding structures, surface water storage has traditionally been the most desirable method of water supply. Given appropriate conditions and management, a reservoir is relatively dependable, pure, and can supply water by gravity at a low cost to the consumer. The Providence Water Supply Board presently receives all water supplies from Scituate Reservoir. The 3,400-acre Scituate Reservoir is surrounded by about 12,000 acres of land owned and managed by the Providence Water Supply Board for water quality control. The water leaving Scituate Reservoir is considered by many to be of the best quality in the country. Given existing technology and the Rhode Island setting, it is believed that additional surface water storage would offer the best potential and economic feasibility to meet projected demands for the Providence metropolitan area. As such, various potential reservoir sites in Rhode Island have been evaluated in the Corps studies (Appendix B, "Plan Formulation").

Environmental considerations for surface water storage are primarily related to the displacement of existing land use at the site, associated natural, cultural and social values, and modification of the quality and quantity of downstream water resources.

3.01.9 Conclusion

The foregoing analysis indicates that surface water development is the only method to satisfactorily meet the predicted water supply needs of the study area. Groundwater development and demand modification, although limited in potential, were seen as desirable methods to be included in a comprehensive water resource management plan because of their high economic and technical feasibility, and public desirability. Consequently, these three methods were studied in more detail toward development of intermediate resource management plans.

3.02 Without Condition (No Federal Action)

The "without condition" alternative used in this report means no Federal participation in the development of solutions to the study area water supply needs, that is, the recommended plan would not be implemented through Federal involvement. This does not, however, restrict local development on much smaller scales to assist in localized water supply problems. The extent of possible local solutions has been described in the Main Report.

The types and magnitude of social, economic and environmental impacts of the "without condition" would differ greatly among communities based on the character of the community and the extent of the deficiency. Impacts would be more severe in those communities with the greater water supply deficiencies (Appendix A, "Problem Identification"). Communities with more adequate water supplies would experience an increased population growth rate as less growth would occur in nearby areas with deficient water supplies. This would increase predicted demands for their public utilities and lands.

The area considered for the development of Big River Reservoir was purchased by the State by eminent domain in the mid-1960's. Should the reservoir not be built, the land would most likely continue as a largely undeveloped area, managed primarily for recreational activities.

Water supply programs for public management would continue as at present, relying on presently developed sources to meet future demands. The Bristol County Water Company would be expected to develop new supplies because of the immediate need for additional capacity in that system. These additional supplies would be obtained through the phased development of groundwater and surface water resources in Rehoboth, MA in addition to implementation of modifications to improve the existing water supply system. Existing surface water and groundwater supplies would supply the needs of the Providence Water Supply Board and Kent County Water Authority service areas until demands exceed the available supplies. The less urbanized communities would continue to utilize private on-lot water systems or construct municipal supply systems through the development of groundwater resources.

The average annual flood losses of $1,986,310 (Sept. 1980 price levels) would continue to result from flooding in the Pawtuxet River Basin. Physical and non-physical damages to homes and local businesses due to flooding would continue.

Recreation resource needs within the State of Rhode Island would continue to increase during the study time frame. However, except for boating and golfing activities, demands would continue to be met with existing resources. Also, demands would increase on facilities in communities surrounding the Big River site.

Table 3 describes in a comparative form the significant social, economic, and environmental impacts of the base condition, "without condition", and Plans A, B, and C.

3.03 Detailed Project Planning

3.03.1 General

The recommended comprehensive water resources development and management plan for the Providence metropolitan area includes: (1) immediate implementation of a demand modification program for the study area; (2) immediate development of groundwater sources in Glocester and Burrillville to serve Foster and Glocester, and in Rehoboth, MA to serve Bristol County; and (3) construction of Big River Reservoir. Flood damage reduction measures and floodplain management objectives in the study area were directed at reducing flood hazards and associated urban flood damages in Coventry (South Branch of the Pawtuxet River), West Warwick, Warwick and Cranston (main stem of the Pawtuxet River).

Recreational resource development was also studied taking into consideration the diversity of recreational needs within the study area and the State of Rhode Island. A fish and wildlife mitigation plan which would offset losses attributable to the development of Big River Reservoir has been developed.

The recommended water resources development and management plan proposed optimizes both the NED and EQ contributions of all measures considered in the intermediate planning phase to satisfy the planning objectives (Section 2.02).

In accordance with Principles and Standards, alternative features and provisions of Big River Reservoir were evaluated for their National Economic Development (NED) and Environmental Quality (EQ) contributions prior to selection. Those found to satisfy both NED and EQ objectives were selected as preferred features and are discussed in the following sections.

3.03.2 Aqueduct

The tunnel method was chosen over a cut and cover option because of the environmental and social degradation associated with creating the channel involved with the cut and cover method. Also, the tunnel was found to be slightly less expensive. (Appendix G, "Design and Cost Estimates").

3.03.3 Pipeline Construction

Construction of a pipeline from the Providence system to Bristol County to supplement initial groundwater development in Rehoboth, MA was selected over additional local development. The existence of

Table 3
Comparative Environmental Impacts of Alternatives
Big River Project, Rhode Island

Effects	Base Condition	Without Condition (No Action)	NED Pla (Plan A
Land Taking Requirements	Big River Management Area owned and managed by the State of Rhode Island - approximately 8,000 acres	No land taking required - Assume that the State of Rhode Island would continue to own and manage the lands.	3,240 a approxi
Site Preparation	N/A	N/A	All gro 6 feet 303.0
Reservoir Pool Modification	N/A	N/A	No Acti
Temporary Construction Impacts	N/A	N/A	Disturb associa
Effects on Wetlands	Forested and scrub/shrub wetlands are found throughout the Big River Management Area.	No inundation of wetlands in Big River Management Area. However, increased usage of existing surface and ground water resources may create adverse impacts during periods of below average precipitation. Short-term impacts during construction of transmission line.	570 acr inundat transmi
Downstream Impacts	Flat River Reservoir and the upper reaches of the North and South Branches of the Pawtuxet are classified Class B by the Rhode Island Division of Water Pollution Control. The mainstem of the Pawtuxet is classified as Class C.	Waste assimilation at downstream discharges would be affected due to reductions in stream flow. Downstream reaches of the Pawtuxet would become worse.	Average Branche Inflows reduced.
Effect on Aquatic Ecosystem	Streams support cold and warm water species. Lower Nooseneck and Big River stocked annually with trout. Warm-water fisheries not managed as populations are self-sustaining.	Significant impacts possible in water bodies because of increased surface and ground water utilization resulting in stresses on existing biota. Assume that State would continue stocking programs.	Inundati and 40 fisheri the po
Effect on Terrestrial Ecosystem	Big River Management Area provides habitat for a variety of wildlife species. Vegetation consists of mixed hardwood-softwood forests and wetland species.	No inundation. Acquisition and construction of transmission mains would impact wildlife resources and habitat in construction areas.	Inundati habitat hardwoo habitat lands a acres o permane construc wells f disrupti construc
Historical-Archeological Impacts	Fourteen small private cemeteries having historical significance, 12 historical sites (including 4 recommended for National Register) and 16 archeological sites of potential significance, are located on the project area.	In the future, other sites may be designated as having historical value.	Sites l inundat
Fish and Wildlife Mitigation	N/A	N/A	Intensi to incr mitigat fisheri
Mitigation Costs	N/A	N/A	TOTAL F TOTAL *State subimp construc
Project Economics	N/A	N/A	Total Total Benef Net

Notes: 1. Base condition year = 1975
2. Period of Analysis = 55 years
3. B/C Ratio = Project Benefits ($)/Project Costs ($)
4. N/A = Not Applicable

rnatives

	NED Plan (Plan A)	EQ Plan (Plan B)	Recommended Plan (Plan C)
State manage	3,240 acres as required for reservoir pool, plus approximately 4,000 acres in watershed area.	Same as Plan A	Same as Plan A
	All growth 2-inches in diameter greater and over 6 feet high would be removed below elevation 303.0 NGVD.	Clearing operations as in Plan A, plus grubbing and stripping of all vegetative growth below elevation 303 NGVD to reduce oxygen demand in the hypolimnion due to reactions resulting from decomposition.	Same as Plan B
	No Action	Construction of subimpoundments in southern portions of the reservoir to create wetland habitat.	Same as Plan B.
	Disturbance in areas of access roads, with associated construction noise and dust.	Same as Plan A.	Same as Plan A.
of es may below	570 acres of wetland habitat would be inundated. Temporary impacts in areas of transmission main construction.	Same as Plan A.	Same as Plan B.
as eam would	Average annual flows on the mainstem and South Branches of the Pawtuxet would be reduced. Inflows into Flat River Reservoir would also be reduced.	Same as Plan A.	Same as Plan A.
es ter ing	Inundation of approximately 20 miles of streams and 40 acres of ponds. Loss of cold-water fisheries in streams and warm-water fisheries in the ponds.	Same as Plan A.	Same as Plan A. Also, temporary disruption of marine biota during construction of transmission line under the Providence and Warren Rivers.
ion of s.	Inundation of approx. 3,000 acres of wildlife habitat which includes approx. 2,300 acres of hardwood, softwood and mixed forests. Other habitat affected includes agricultural and open lands and sand and gravel areas. Approx. 30 acres of land taking each for temporary and permanent easements for transmission line construction in Glocester and Foster, and for wells in Glocester, including temporary disruption of habitat in these areas during construction.	Same as Plan A	Same as Plan A. Also, taking of an additional 15 acres of easements for construction of transmission facilities from the Providence system to serve Bristol County.
ed as	Sites listed under Base Condition would be inundated by Big River Reservoir.	Same as Plan A	Same as Plan A
	Intensive wildlife management on watershed lands to increase and maintain resources. Limited mitigation measures for wetlands and cold-water fisheries.	Intensive wildlife management on watershed lands, additional development of a cold-water fishery, construction of subimpoundments in southern portions of the reservoir to create wetland habitat. Road relocations to provide access to recreation areas.	Same as Plan B.
	TOTAL FIRST COSTS $223,700* $1.2 million* TOTAL ANNUAL COSTS $318,700 *State of R.I. estimated cost of construction of subimpoundments at $90,000. Corps estimates construction of subimpoundments at $1,070,000.	Same as Plan A	Same as Plans A and B.
	Total Project Costs $59,081,000 Total Annual Costs 5,998,000 Benefit-Cost Ratio 1.25 Net NED Benefits 1,527,000	Total Project Costs $65,379,000 Total Annual Costs 6,531,000 Benefit-Cost Ratio 1.15 Net NED Benefits 994,000	Total Project Costs $63,541,000 Total Annual Costs 6,455,000 Benefit-Cost Ratio 1.17 Net NED Benefits 1,070,000

institutional arrangements would make the pipeline system easier to implement as a result of less extensive interstate agreements. The development of additional groundwater supplies in Rehoboth, MA would result in additional environmental impacts related to the drawdown of the groundwater table, which would not occur should the pipeline be constructed.

The future needs of the Bristol County Water Company would be served from the Providence water supply system by construction of transmission facilities in various public ways and permanent easements, with underwater crossings of the Pawtuxet River, Providence River, and the Warren River. (Refer to Main Report for a detailed description of the pipeline facilities).

3.03.4 Reservoir Size

3.03.4.1 Water Supply Pool

Alternative water supply pool sizes studied range from 32,200 to 73,600 acre-feet of storage, providing 25 to 36 mgd safe yield of water supply, respectively. This difference in yield is obtained by the inundation of an additional 800 acres of land. The larger size was selected as it would provide an extra yield that would preclude further development to meet future demands, and is more economically efficient. Upland and wetland habitat would be inundated.

3.03.4.2 Flood Control

Flood control at Big River Reservoir would consist of adding 3 feet of elevation to the reservoir, or 9,500 acre-feet of storage which is equivalent to about 6 inches of runoff from the watershed. The environmental impacts of this addition would not be significant as flood control inundation would be short-term in duration and would be intermittent. Economic benefits in the towns of Warwick, West Warwick and Cranston, Rhode Island would be significant.

3.03.4.3 Conservation Storage

Conservation storage is provided below water supply pool to allow for sedimentation and to enhance water quality, particularly during reduced water levels. 12,300 acre-feet of conservation storage would be provided which would increase maximum depth of the reservoir by about 7 feet. With conservation storage, the reservoir would be deeper and colder, providing improved water quality and a cold-water fishery. Upland habitat would be inundated. Conservation storage was found to be economically desirable because it would provide water supply during emergency conditions.

3.03.5 Recreation

3.03.5.1 Introduction

Through analysis of the needs, opportunities, benefits, and potential impacts of recreation in association with Big River Reservoir, the Corps determined that sufficient need and opportunity existed, and that a recreation plan be recommended as a project purpose. Option III has been recommended based on its ability to provide maximum recreation development at the site, and also the positive impact on local recreation opportunities. A summary of the recreation options is presented below. Detailed discussions of the recreation demands of the study area and the optional plans for meeting these demands is contained in Appendix H, "Recreation and Natural Resources." Further input, analysis and planning would develop a final plan which would be designed to optimize use of the available natural resources without significant degradation of environmental quality, particularly the reservoir water quality.

A detailed Master Plan for development of the recreation resources of the project would be prepared, at such time as advanced engineering and design is undertaken. A Master Plan would be prepared in conjunction with development of the Phase I General Design Memorandum, if so authorized.

3.03.5.2 Option I

This plan would prohibit all access to the site for recreation. Existing and future recreation demands would have to be transferred from the site and absorbed by other recreation facilities in the area.

3.03.5.3 Option II

Under this plan, most future recreation needs would be satisfied by providing boating, fishing, hunting, swimming, hiking, horseback riding and picnicking. The Zeke's Bridge area on Flat River Reservoir would be utilized for boating, fishing, picnicking and swimming. The Big River Reservoir recreation area would be developed for picnicking, shoreline fishing and access to multi-purpose trails. Carr Pond would be developed for picnicking and shoreline fishing. This option attempts to meet the "without condition" recreation needs while also minimizing water quality impacts due to recreation activities.

3.03.5.4 Option III

This plan includes all the activities discussed under Option II and adds some activities and areas to provide a maximum recreation development plan for the reservoir. Additional facilities at Big River Reservoir (boating), Carr Pond (swimming, boating, trails), Phelps Pond (swimming, picnicking), and Hungry and Harkney Hills (camping) would allow this plan to meet projected demands, including those generated by reservoir development.

3.03.6 Fish and Wildlife Mitigation

3.03.6.1 Introduction

The following sections present the Corps' proposed plan for mitigation of fish and wildlife losses attributable to the development of Big River Reservoir. This plan incorporates many of the recommendations provided to the Corps by the U.S. Fish and Wildlife Service (USFWS), the Rhode Island Department of Environmental Management (D.E.M.), and consultant's mitigation reports.

The U.S. Fish and Wildlife Service, in line with its responsibilities to determine damages to wildlife resources and to recommend measures for wildlife mitigation and compensation, has submitted to the Corps of Engineers its Fish and Wildlife Coordination Act Report (USFWS, 1979; Appendix H, "Recreation and Natural Resources," 1980).

The Rhode Island D.E.M. has contributed to mitigation planning efforts by providing wildlife and fisheries information, consultation time, and by reviewing draft documents for comment.

The Corps has also published a consultant's wildlife mitigation report (Appendix H, "Recreation and Natural Resources," 1980) as part of the Environmental Impact Statement for the project. This report presents methods for wildlife mitigation and management.

The USFWS Coordination Act Report recommends fish and wildlife mitigation measures for those lands remaining in the watershed between the reservoir pool and the State watershed boundary, based on the Habitat Evaluation Procedures (HEP). The report also recommends, based on HEP, that an additional 5800 acres of forest and wetland habitat be acquired and managed to offset losses due to project implementation. This action represents 100% mitigation of wildlife losses.

The proposed plan incorporates several measures recommended by the USFWS for management of the reservoir watershed lands. However, it does not recommend the acquisition of an additional 5800 acres of lands.

In accordance with the Fish and Wildlife Coordination Act, the Corps must develop a plan which presents justifiable means and measures for wildlife resources that should be implemented to obtain maximum overall project benefits. This does not necessarily have to include 100% mitigation of lost resources. For this feasibility stage of study, proposed management of the surrounding reservoir lands represents the level of fish and wildlife mitigation which the Corps feels is viable and justifiable and in the public interest in conjunction with the proposed Big River Reservoir Project. This is also in keeping with Congressional policy regarding mitigation which does not support recommendations for land acquisition which is not contiguous with the project.

The Rhode Island D.E.M. supports off-site mitigation for the Big River Reservoir, and has stated that the acquisition of 1,500 to 2,500 acres in the Pawcatuck River watershed would be necessary for complete mitigation, in addition to on-site management of fish and wildlife resources. (Addenda and Errata, Appendix H, "Recreation and Natural Resources"). The proposed mitigation plan does not recommend the State's proposal for additional acreage for the same rationale as explained above in regard to the U.S. Fish and Wildlife Service's mitigation plan.

3.03.6.2 Proposed Terrestrial Management Plan

Deciduous/Evergreen forest/shrubland habitat

Approximately 3,000 acres of wildlife habitat would be inundated by Big River Reservoir. There would remain approximately 4,000 acres of deciduous/evergreen forest/shrubland habitat within State ownership that can be managed to mitigate for loss to wildlife resources. In the southern portion of the reservoir watershed bordered by the New London Turnpike (Plate 9, Main Report) approximately 2,000 acres of upland habitat would be available for intensive wildlife management. The area would have limited access and would be fairly isolated from other portions of the reservoir that would be used for recreational purposes. Wildlife management practices would include such measures as selective cutting on a 10-year basis, retention and creation of den trees, mast trees, low cover and brush piles, pruning and thinning, prescribed burns and plantings. This area would also be managed for small game, deer, and waterfowl hunting with access provided on a seasonal basis.

The remaining 2,000 acres would also be managed for wildlife employing methods as described above, however, only to an extent that would be compatible with the recreational use proposed for the area. Portions of the Big River Reservoir watershed area would be developed for picnicking, fishing, hunting, and multi-use trails, with camping facilities at Hungry and Harkney Hill Roads. Management in these areas would emphasize improving habitat for those wildlife species pleasing to people (songbirds, etc). The area north of I-95 would be managed as a wildlife sanctuary.

Sand and gravel pits, agricultural and open lands

Management practices would be carried out for wildlife species typical of open country. The U.S. Fish and Wildlife Service assumed that the State would remove sand and gravel deposits before project completion and the areas of pits would increase from 184 acres to 368 acres in the portion between the reservoir pool and the State boundary. The USFWS recommended that pit areas should be graded, topsoiled and seeded in addition to plantings for cover. The CE proposal would provide for grading only. Grading would allow natural succession of native vegetation types which would increase species diversity and provide nesting, denning, or perching sites for many wildlife species.

The 250 acres of agricultural and open fields would be kept open with management directed toward increasing existing food supplies. For further discussion on management practices for this type of habitat, see Appendix H, "Recreation and Natural Resources," CE, 1980, USFWS Coordination Act Report, Sept. 1979.

Wetlands

Construction of Big River Reservoir would inundate approximately 570 acres of wetland habitat (National Wetland Inventory, USFWS, 1979). The USFWS stated in their 1979 Coordination Act Report that this loss would be extremely difficult to mitigate even with the acquisition and management of lands outside the study area.

Approximately 20 acres of scrub/shrub wetland habitat would remain in the area between the reservoir pool and state ownership boundary (USFWS, 1979). Management practices recommended by the U.S. Fish and Wildlife Service would consider the construction of low level dikes with water control structures or creation of potholes to maintain approximately 10-25 percent of the area in permanent shallow water. Small openings would be created in heavily overgrown areas to increase habitat diversity.

There would also be approximately 126 acres of forested wetland remaining after inundation (USFWS, 1979). This habitat would be managed the same as the scrub/shrub habitat. In addition, trees would be girdled to maintain a canopy closure of 50-60 percent, and mast trees and all potential den trees would be retained. Wood duck boxes would be installed where needed.

Along with the above management practices, creation of subimpoundments at the edge of the pool (below elevation 300 ft. msl) are to be the method adopted to partially mitigate wetland losses due to project implementation. The exact level of wetland mitigation is still an unknown quantity; however, mitigation of losses to wetlands can be achieved. Three sites, totalling approximately 90 acres, have been located by the USFWS as possible locations for subimpoundments (Plate 9, Main Report). They are:

1. An approx. 8 acre site located where the Congdon River would enter the reservoir which is now dominated by deciduous and evergreen forest. Elevations in this area range from 296 to 300 feet msl.

2. An approx. 12 acre site located upstream from Sweet Pond near the New London Turnpike which is presently a forested wetland. Elevations range from 292 to 300 feet msl.

3. An approx. 70 acre site located in the Mud Bottom Brook area. This area is also a forested wetland with an elevation between 292 and 300 ft. msl.

For further discussion of the proposed development and management of these subimpoundments, refer to Appendix H, "Recreation and Natural Resources," CE, 1980, USFWS Coordination Act Report, Sept. 1979.

Table 4 displays the estimated development and operation and maintenance costs for the proposed USFWS terrestrial management plan. The 1979 figures shown in Table 14 of the USFWS Coordination Act Report in Appendix H have been revised to reflect 1981 dollars.

The Rhode Island D.E.M. has indicated that upland habitat management could be phased in year by year at an annual cost of $85,000 (1981 dollars). In regard to marsh development, if the material on the site and other factors were such that the dams could be constructed under force account using State equipment the initial cost would be $90,000 (1981 dollars). Should the work be let out for contract, the initial cost estimate is $150,000. Annual maintenance costs for wetland development by the State would be $10,000 a year.

Table 5 shows estimated development and first costs for the proposed CE terrestrial management plan, and Table 6 shows estimated annual operation and maintenance costs.

3.03.6.3 Proposed Fisheries Management Plan

The USFWS recommended in their 1979 Coordination Act Report that the Big River Reservoir be managed for both cold-and warm-water fisheries. The installation of a multiple-level outlet along with stripping organic material from the bottom of the reservoir would provide a two-story fishery with warm-water species in the warmer upper levels and cold-water species generally spread throughout the pool, except in the summer.

The Big River is currently stocked with 1500-1600 "catchable" size trout annually by the State of Rhode Island. Current costs for stock from the Federal hatchery are $1.00/trout, 8" in size. A cold-water fishery would be established through stocking the reservoir. The State of Rhode Island indicated that the stock would have to come from the Federal hatchery in N. Attleboro, MA. The Rhode Island D.E.M. estimated that 50 trout/acre of fingerling size would be required for the reservoir. Current costs for fingerling size brown trout range from 22¢ apiece for the 2"-3" size to 45¢ apiece for the 4"-5" size. The water quality of the reservoir would be suitable to support a viable trout fishery.

Landlocked salmon should be considered for introduction. However, there would be problems in establishing a viable smelt forage population because of the potential for difficulty in smelt developing in the reservoir beyond the larval stage. A closely-related cold-water forage species such as alewife could prove to be more successful than smelt. (Rhode Island D.E.M., personal communication).

Table 4

Estimated Development and Operation and Maintenance Costs

Proposed USFWS Terrestrial Management Plan

(1981 Dollars)

Additional Lands Habitat Type	Acquisition	Development	Annualized Operation and Maintenance
Evergreen Forest (1,268 acres)	$800/acre = $1,014,400	$56.50/acre = $71,642	$7,608
Scrub/Shrub Wetland (2,267 acres)	$300/acre = $ 680,100	$180/acre = $408,060	$4,500
Forested Wetland (2,273 acres)	$300/acre = $ 681,900	$180/acre = $409,140	$6,800
SUBTOTAL	$2,376,400	$888,842	$18,908

Project Lands Habitat Type		Development	Annualized Operation and Maintenance
Deciduous/Evergreen Forest/Shrubland (Approx. 4,000 acres)	----------	$56.50/acre = $226,000	$24,660
Sand and gravel pits (368 acres)	----------	$6800/acre = $2,502,400	$ 2,750
Agricultural and open lands (212 acres)	----------	$56.50/acre = $11,978	
Wetlands (146 acres)	----------	$180/acre = $26,280	$ 1,228
Subimpoundments (90 acres)	----------	$45/acre = $4,050	----------
	SUBTOTAL	$2,770,708	$28,638
TOTAL ACQUISITION	$2,376,400	TOTAL DEVELOPMENT $3,659,550	TOTAL O&M $47,546

Table 5

Estimated Development and First Costs
Proposed CE Terrestrial Management Plan (1981 dollars)

ITEM		
Construction of Subimpoundments	$90,000*	$1,070,000
Reclamation of sand and gravel pits	$50,000	$ 50,000
TOTAL FIRST COSTS	$140,000	$1,120,000

*The State of Rhode Island estimated that construction of three subimpoundments would cost a total of $90,000. The Corps estimates that construction of these subimpoundments would cost $1,070,000.

Table 6

Estimated Annual Operation and Maintenance Costs
Proposed CE Terrestrial Management (1981 dollars)

ITEM		UNIT COST/INCOME
Personnel Requirements		
One full-time wildlife biologist		$22,600/year
One full-time maintenance engineer		$22,600/year
One part-time forestry and wildlife technician (seasonal when practical)		$12,500/year
One part-time maintenance engineer		$12,500/year
	SUB-TOTAL	$70,200/year
Equipment Costs		$38,200/year
Habitat management		$99,000/year
Road maintenance		$10,000/year
Operating costs		$10,000/year
	SUB-TOTAL	$157,200/year
	TOTAL ANNUAL COSTS	$227,400/year

After the reservoir is filled, the warm-water species already present in the system would reproduce and grow at a greater than normal rate, and will level off when the carrying capacity of the reservoir is reached. Largemouth bass, chain pickerel, yellow perch, brown bullhead, and sunfish would be present. Because of the nutrient availability and rapid growth of the existing populations, a warm-water species stocking program should not be necessary. The physical characteristics of the reservoir would be suitable for the introduction of smallmouth bass. However, a limiting factor in the reproductive capability of this species is the acidity of the water as smallmouth bass are affected by acidity before other species. The Rhode Island D.E.M. has found that the pH level in most water bodies in the area is becoming lower over time.

Stocking and management programs would be the responsibility of the Rhode Island Department of Environmental Management, Division of Fish & Wildlife. The Rhode Island D.E.M. has estimated that initial costs for the cold water fishery, including a parking lot, sanitary facilities, check station, salaries for attendants and research surveys as well as fish would be $73,800. Annual costs to maintain the fishery and facilities would be $43,800 in 1981 dollars. (See Addenda and Errata to Appendix H, "Recreation and Natural Resources.")

Table 7 shows estimated development and annual operation and maintenance costs for the proposed CE fisheries management plan.

Table 8 displays a summary of total initial and total annual costs for the Corps proposed fish and wildlife mitigation plan.

Table 7

Estimated Development and Annual Operation and Maintenance Costs
Proposed CE Fisheries Management Plan (1981 dollars)

DEVELOPMENT COSTS	
Cold-water fishery facilities and equipment	$83,700
ANNUAL COSTS	
1 full-time fisheries biologist	$22,500/year
1 part-time fisheries technician	$12,500/year
1 part-time maintenance engineer	$12,500/year
Maintenance of fisheries and facilities	$43,800/year
TOTAL ANNUAL COSTS	$91,300/year

Table 8

SUMMARY OF TOTAL COSTS FOR CE FISH AND WILDLIFE MITIGATION PLAN (1981 Dollars)

FIRST COSTS		
Construction of Subimpoundments	$90,000*	$1,070,000*
Reclamation of sand and gravel pits	$50,000	$50,000
Cold-water fishery facilities and equipment	$83,700	$50,000
TOTAL FIRST COSTS	$223,700	$1,170,000*

ANNUAL COSTS	
Terrestrial Management Plan	
Personnel	$70,200/year
Equipment Costs	$38,200/year
Habitat management	$99,000/year
Road maintenance	$10,000/year
Operating costs	$10,000/year
Fisheries Management Plan	
Personnel	$47,500/year
Maintenance of fisheries and facilities	$43,800/year
TOTAL ANNUAL COSTS	$318,700/year

*The State of Rhode Island estimated that construction of three subimpoundments would cost a total of $90,000. The Corps estimates that construction of these subimpoundments would cost $1,070,000.

4.00 AFFECTED ENVIRONMENT

4.01 Introduction

This section focuses on the Big River Management Area, with emphasis on that area proposed for inundation and the more significant resources that would be affected should the project be implemented. The Main Report contains a summary of the relevant factors describing the overall study area. Detailed descriptions of the study area are found in the supporting technical appendices.

4.02 Environmental Setting

Between 1963 and 1966 the State of Rhode Island obtained by eminent domain the 8,300 acre[1] Big River Management Area (Figure 2) to protect the proposed Big River Reservoir area from development. About 7,600 acres are within West Greenwich, Rhode Island (about one fourth of the town's total area). Rivers flowing through the area include the Big, Nooseneck, Congdon, and Carr Rivers. Big River flows into Flat River Reservoir in Coventry, Rhode Island below which begins the south branch of the Pawtuxet River which ultimately flows into the main stem Pawtuxet. The proposed Big River dam would be located at the confluence of Big River and Flat River Reservoir and would inundate about 3,240 acres in the 29.7 square mile Big River watershed.

Interchanges where Interstate Highway 95 crosses the proposed site provide easy access by automobile to Providence, Rhode Island, approximately 15 miles northeast from the Big River Management Area.

Approximately 440 tenants have remained in the management area and are renting their residences from the State with the knowledge that relocation would be necessary if the planned development occurs. Many of the buildings in the area have been neglected; some are in ruin, others have been burned. Litter and junk are plentiful along many of the small roads that crisscross the site. The area has remained undeveloped; a "backwoods" in the heart of the State.

The old Hopkins Mill, which was entered into the National Register of Historic Places in 1964, was destroyed in September 1978. Two old unpaved roads, the New London Turnpike and Sweet Sawmill Road, and the old Nooseneck Factory sites have been recommended for inclusion into the National Register of Historic Places.

Since purchased by the State, the undeveloped nature of the Big River area has increasingly prompted its usage for outdoor recreational purposes. However, because of a lack of commitment to recreational management, resources are only informally used by local residents who

[1]The numbers reported in this report are generally "rounded off" to give a general impression of the size of various components for comparative discussion--many numbers have been obtained from the State of Rhode Island. Numbers given in various other reports may not be entirely consistent due to use of different mapping scales and delineation errors which are compounded when computed into areal figures.

are familiar with the area. The rivers, streams and ponds are used for boating, fishing and swimming. The wetlands and adjacent woods, which cover approximately 90 percent of the proposed inundation area, are used for hunting. The sand dunes, fields and trails are popular with motorcyclists, snowmobiles and horseback enthusiasts.

The study area is part of the White Pine-Hemlock-Hardwood Forest Region and is located near the southern boundary of the New England Section of this region. The uplands are dominated by oak forests, white pine stands and mixtures of upland hardwood, pine, and wetland species. Open areas such as farmland, old fields, and sand or gravel areas contain plant communities in various stages of development from grassland to shrubland.

Open land areas have either been recently disturbed or are disturbed on a recurring basis as a result of mowing, agriculture or trampling. The USDA Soil Conservation Service (SCS) has indicated, based on 1978 soil surveys, that over 8,000 acres of the Big River Management Area is either prime farmland or farmland of statewide importance. Forest and open land constitute 70.2 percent of the total study area.

Most commonly observed small mammals in the study area include red squirrels, gray squirrels, and chipmunks. The Rhode Island Department of Environmental Management lists whitetail deer, snowshoe hare and cottontail rabbit as occurring in the study area.

The headwaters of most of the streams support native brook trout, however, the biomass of this species is low. (Rhode Island D.E.M., 1979). The remaining portions of the streams support both cold-water and warm-water species. The larger streams, such as Big River and Nooseneck, are stocked annually with trout. Warm-water species are self-sustaining and not intensively managed. Flat River Reservoir supports a warm-water fishery.

No habitats of rare or endangered species have been indicated in the aquatic and terrestrial studies. One fish species, the Swamp Darter, was found in the area; but although never before reported from Rhode Island, it is not considered endangered by any Federal or State criteria.

Minor commercial activities within the proposed reservoir area include a golf course, the operation of a drinking establishment, and timber, sand and gravel removal operations under agreement with the State. The lumber resources within the area proposed for inundation are estimated to have a value of aground one-half to one million dollars if cut and sold prior to reservoir construction.

4.03 Significant Resources

One significant nonrenewable resource within the Big River Management Area of local and state-wide importance is the extensive sand and gravel deposits. It is estimated that 30 million cubic yards of sand and gravel exist within the management area. The total commercial value of these sand and gravel resources, based on information supplied by local contractors, is approximately $30-45 million at current dollar values. Three private contractors are currently removing one million

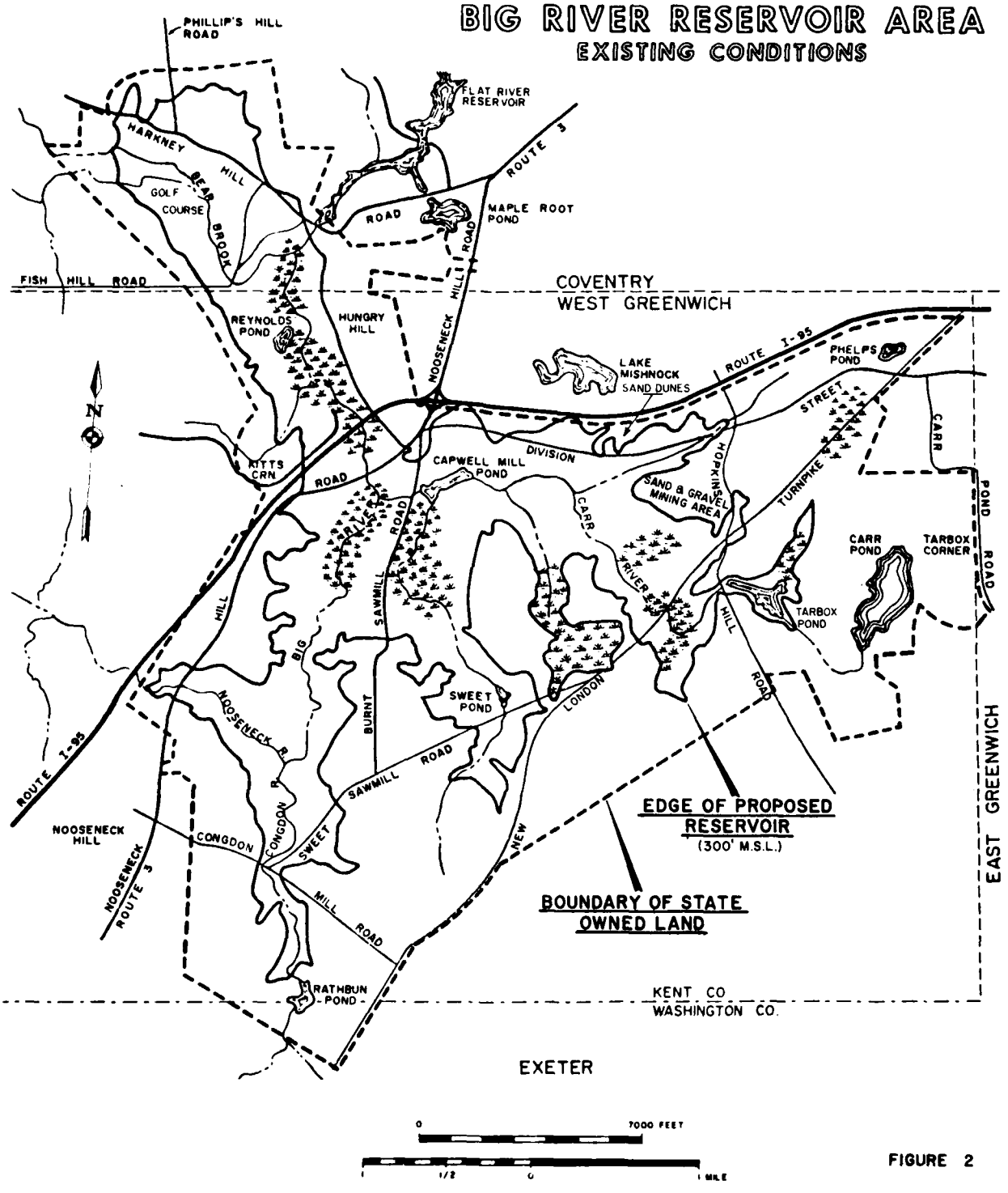

BIG RIVER RESERVOIR AREA
EXISTING CONDITIONS
PHILLIP'S HILL ROAD
FLAT RIVER RESERVOIR
HARKNEY HILL
BEAR BROOK
GOLF COURSE
ROUTE 3
MAPLE ROOT POND
FISH HILL ROAD
COVENTRY
WEST GREENWICH
REYNOLDS POND
HUNGRY HILL
NOOSENECK HILL ROAD
LAKE MISHNOCK SAND DUNES
ROUTE I-95
PHELPS POND
N
KITTS CRN
ROAD
CAPWELL MILL POND
DIVISION STREET
CARR
HOPKINS HILL ROAD
SAND & GRAVEL MINING AREA
TURNPIKE
CARR POND
TARBOX CORNER
POND ROAD
RIVER
SAWMILL ROAD
BIG
TARBOX POND
HILL
SWEET POND
LONDON ROAD
BURNT
NOOSENECK R
ROUTE I-95
CONGDON R
SAWMILL ROAD
NOOSENECK HILL
CONGDON
NOOSENECK ROUTE 3
SWEET
MILL ROAD
NEW
EDGE OF PROPOSED RESERVOIR
(300' M.S.L.)
BOUNDARY OF STATE OWNED LAND
RATHBUN POND
KENT CO.
WASHINGTON CO.
EAST GREENWICH
EXETER
0
7000 FEET
1/2
0
1 MILE

FIGURE 2

cubic yards each, under agreement with the State, a task that should be accomplished during 1983.

At this time, the State of Rhode Island is preparing guidelines for a study to determine if it would be feasible to remove more or all of the sand and gravel prior to construction of a reservoir and to store it at another site. Because the State owns the land on which the sand is located, and the fact that the value of sand and gravel for construction purposes increases due to its scarcity in the study area, the findings of the upcoming study are expected to result in a resource management plan designed to mitigate the potential loss of the resource.

The proposed Big River site is extensively used for a variety of recreational purposes by residents of the surrounding area. Since coming under State ownership over ten years ago, it has been heavily used for recreation. Although the majority of people who visit the site come from the local area, many travel from Providence and other communities in the region.

The relatively undeveloped natural surroundings at the Big River site have been estimated to offer about 5 percent of the horseback riding capacity, 10 percent of the hunting capacity, and about 10 percent of the hiking capacity of the State of Rhode Island.

The sport fishery potential at Big River has differing levels of value, depending on the type of habitat. The ponds support excellent sport fisheries for pickerel, sunfish, largemouth bass and perch. However, the streams offer a limited warm-water fishery potential as compared to the cold-water stream fishery due to a successful trout stocking program.

The natural resources of the Big River site were evaluated in detail. These evaluations included vegetation surveys, wildlife habitat studies, and aquatic ecosystem surveys (Appendix H, "Recreation and Natural Resources"). The significant fish and wildlife resources of the Big River area and the alternative reservoir sites are summarized in Table 9.

TABLE 9

NATURAL RESOURCES

ECOSYSTEMS		VEGETATION/HABITAT CATEGORIES	PREDOMINANT VEGETATION	PREDOMINANT WILDLIFE*	SIGNIFICANT FACTORS** AT STUDY SITES: BIG RIVER 3280 a(acres)33 mgd	WOOD RIVER 900 a-26 mgd	MOOSUP 510 a-12 mgd	BUCKS HORN 510 a-5 mgd
TERRESTRIAL	(1) Open Land	Dry/sandy areas Abandoned fields Pasture Disturbed areas	Hawkweed Quack grass Timothy Yarrow Small trees	Cottontail rabbit, bobwhite quail, ringnecked pheasant (3), meadow voles, some song birds, red fox(2,3) weasel(3)	325 a 10% of area	26 a 3% of area	47 a 9% of area	6 a 1% of area
	(2) Woodlands		(1)=Overstory (2)Understory					
		Softwood forest	(1) White pine & pitch pine (2) Young pine & oak, huckleberry & low bush blueberry	Red squirrel, snowshoe hare	872 a			
		Hardwood forest	(1) Red & white oak (2) High bush & low bush blueberry, huckleberry princess pine	White-tailed deer(1,3,4) gray squirrel white footed mice	832 a	691 a 78% of area	333 a 62% of area	294 a 62% of area
		Mixed forest	(1) Oaks & pines (2) Young oaks & pines, *low bush blueberry*, sheep laurel, sheep berry	Raccoons (3,4) *Ruffed grouse* *American* woodcock, most diverse for songbirds, owl(1,3)	601 a			
					2306 a 73% of area			
	(3) Wetlands	Swamps	Red maple, white pine, pepper bush, button bush, high bush blueberry, pickerel weed	Wood duck Songbirds	524 a 17% of area	166 a 19% of area	159 a 29% of area	178 a 37% of area
		Marshes	Sedges, rush, burreed, pondweed, pond lily	Black duck, kingfisher, herons, otter, songbirds				
AQUATIC	(4) Water	Lentic (Still water)	Green algae, Desmids, Blue green algae } algae Also, fringe marsh (see above) Vegetation present in many areas.	Wildlife as indicated above and aquatic organisms: Fish include bridle shiner, golden shiner, pumpkinseed, banded sunfish, creek chubsucker, white sucker, fallfish, brown bullhead, yellow perch, swampdarter, brook trout, pickerel, largemouth bass	Combination of streams & several ponds. 19.7 stream miles inundated. 5.4 miles considered "fishable".[1] Class B. Fishing marginal.	Almost entirely lotic. Streams rated Class A. Regarded as best trout stream in RI. 6 stream miles inundated.	One large pond. Less lotic. Provides cold water fishing. Rated Class A. 5.3 stream miles inundated.	Mostly small streams & swamps. Considered Class A. Considered good brook trout spawning area. 2.3 stream miles inundated.
		Lotic (Running water)	Same as above but diatoms are dominant algae species					

* When a species is followed by numbers in parenthesis, that species requires or is significantly enhanced by the presence of the habitat number as indicated on the left margin; i.e., water = (4), wetland = (3), woodland = (2); the name appears in the habitat of most importance, when name appears in more than one, they are @ of equal importance.
Scientific names of all species listed here are found in App.H, Vol. 2 & 3.

** Numbers (acreage, percent) are estimates - other estimates may not be the same; a = acres, mgd = million gallons per day safe yield.

[1] Personal communication, Richard Guthrie, RI Dept. Fish & Game.

5.00 ENVIRONMENTAL EFFECTS

5.01 Introduction

The scope of this chapter focuses on analysis of the predicted effects of Big River Reservoir. A level of detail has been presented to offer decision makers and the general public a comprehensive understanding of the significant trade-offs and alterations that would be incurred should the Big River Reservoir be developed. Those with greater interest in a particular topic are referred to more detailed information available in the various technical appendices.

5.02 Socio-Economic Effects

5.02.1 Demography

Development of Big River Reservoir would fulfill the intended State land use plans for the Big River Management Area. The plan would allow inundation of the 3,240-acre impoundment site. It would also provide watershed protection and water treatment facilities on the additional 5,320-acre State-owned lands surrounding the reservoir site. Approximately 440 people are now residing on these lands; 306 are scattered throughout the area in houses rented from the State and 134 are living in a trailer court at the water treatment plant site. They have been allowed to reside on the State-owned lands with the knowledge (and under conditions) that relocation would be necessary should the Big River Reservoir development occur.

The fulfillment of the study area's water supply needs would have even greater significance by allowing predicted population distribution and growth and concomitant economic development to occur throughout the study area.

Present zoning requirements have almost eliminated development within the 100-year floodplain. However, new growth is allowed at or above this level even though it could be damaged by a major flood. Big River Reservoir will provide additional safeguards to new residences, and commercial and industrial firms.

5.02.2 Economics

The major commercial activity within the area that would be precluded by reservoir construction is the sand and gravel extraction operation (Figure 2). Value of the reservoir and the effects of eliminating the mining of sand and gravel deposits on the area's economy acquire increased significance when weighed against the predicted scarcity of sand and gravel for construction purposes in southeastern New England, and in particular, Rhode Island. Those contractors currently involved in excavation operations at the Big River site claim that this source provides the highest quality sand and gravel for the lowest cost possible in Rhode Island. Although none of the three contractors employ any workers solely to complete their contractual agreement with the state, several of their employees are involved in that operation at various times. While two of the three contractors regard their excavations in the Big River areas as a small portion of their overall operation, one claimed that his

business was largely dependent on the contract to remain profitable. Alternative sources of sand and gravel exist, but involve much greater transport distances at greater expense. Transportation costs have been estimated at $30 per hour per truckload of approximately 20 cubic yards. It is also estimated that one hour is required to complete a round trip delivery for each additional seven to eight mile distance from the source to the user. These additional transportation costs are reflected in the price of sand and gravel in the local market, and are therefore passed on to the construction industry.

Curtailment of sand and gravel removal at the Big River site would have an impact on the regional economy, however, the severity of that impact would depend on how the State of Rhode Island decides to manage these resources.

Other less significant commercial activities within the proposed reservoir area include a golf course, a bar, and timber harvesting operations. The economic impact on the region due to the loss of these activities would be minimal.

Temporary economic benefits would be expected in the local area during the active construction phase. A project of this magnitude would require a fairly large construction work force and may result in some permanent and temporary job opportunities in the surrounding area.

The most significant economic consideration in the construction of Big River Reservoir is the actual cost of implementation. Cost estimates for the reservoir which would be constructed in the year 1995, range from $123,238,000 to $141,409,000 (1979 dollars) depending on the plan selected. In present worthed dollars, adjusted for the time which would elapse between 1980 and 1995 construction, these same estimates would range from $42,383,000 to $48,632,000. It should be noted that the overall plans being considered involve several features such as treatment facilities, transmission facilities, groundwater development, and a demand modification program which are not included in the reservoir cost estimates because they are not a Federal responsibility.

The overall economy of the area would be improved as a result of flood control storage. The additional length of construction time and the use of more equipment would increase the utilization of the local construction industry. Secondary benefits would be evident with local merchants and floodprone industrial and commercial firms.

5.02.3 Transportation

Interstate 95, the main transportation route crossing the Big River Site, was constructed above the proposed reservoir pool level and therefore would not present any adverse social and economic impacts (Figure 2). The embankment along I-95 in the Big River watershed would, nevertheless, require the following modifications should the reservoir be constructed:

(1) Route 3 (Nooseneck Hill Road) would be relocated along the I-95 embankment where it crosses Big River;

(2) runoff control and stilling basin facilities would be desirable along the highway to prevent uncontrolled contamination of the reservoir from deicing salts, road grit and associated contaminants, and the possibility of a hazardous waste spill; and,

(3) the embankment would require stabilization work to prevent excessive reservoir induced erosion that might affect highway stability.

The only other road relocation currently anticipated would be Harkney Hill Road. This could be accomplished by constructing a bridge to replace Zeke's Bridge and a new road along the edge of the reservoir, or, by utilizing Hill-Farm Road and its bridge over Flat River Reservoir and connecting it across Rock Hill to Harkney Hill Road outside the reservoir lands. Further studies would determine the most desirable alternative.

Other roads within the area would probably not require extensive relocation. Sub-impoundment dikes on the Carr and Congdon Rivers would allow contiguous access along Hopkins Hill and Congdon Mill roads, respectively.

The effect of flood control storage on downstream transportation systems would be beneficial as the likelihood of inundation would be decreased.

5.03 Aesthetics

Clearing the reservoir site of woody vegetation would produce a bare ground/shrub/sapling landscape prior to reservoir filling. This would encourage erosion and subsequent turbidity and nutrient loading of Big River and a portion of Flat River Reservoir. Erosion control techniques would be recommended to minimize this impact. Contractors would be required to landscape construction scars in areas above the pool line and maintain acceptable water quality through runoff control techniques (404 Evaluation, Section 230. 4-2). Construction of the dam and associated facilities would also produce similar effects. The noise associated with both clearing and construction activities would be heard by nearby residents and travelers. These effects would be evident only during the 4-year construction period.

Subsequent inundation would have the most direct aesthetic impact: total alteration of the valley floor into a large body of water. The acceptability of this effect is highly subjective. A resident, hunter, or fisherman of the Big River site might regard the change as an obtrusive reminder of the irreversible loss of aesthetic value. A traveler on I-95 might, however, find the reservoir a pleasant element of diversity and beauty in the forest-covered hills and valleys that dominate the Rhode Island landscape.

Preservation of aesthetic value on project lands would be a key element in the final detailed design. Access roads would be constructed to achieve scenic enhancement through proper location, alignment and minimum cut and fill. Conservation practices such as fertilizing, reseeding and mulching eroded sites, stabilizing reservoir banks, and reclaiming mining areas would prevent aesthetic (as well as water quality) degradation.

5.04 Cultural Resources

Cultural resources are defined as any building, site, district, structure, object, data (submerged or terrestrial) or other material significant in history, architecture, science, archaeology, or culture. Historical and archaeological sites are physical remains of past cultures. Analysis in situ allows reconstruction of the culture of historic and prehistoric societies.

The Big River Cultural Resource Reconnaissance (Appendix I) conducted in 1978 by the Corps includes a preliminary predictive study of archaeological sensitivity within the reservoir land-taking and an inventory of historic resources within those bounds. This study located 12 possibly significant historic features (including the New London Turnpike, Sweet Sawmill Road, and the Nooseneck Factory sites already recommended for the National Register of Historic Places) within the impoundment area. If these or others are found to be of national significance, impacts of construction or inundation would be mitigated through intact removal and/or architectural recording. Fourteen small cemeteries within the inundation area have been found to have historic or scientific value. Relocation would be recommended in a manner consistent with this cultural value. In addition, about 16 recorded sites of potential archaeological significance are within the inundation area. Mitigation of impacts on such sites could be achieved through modification of construction activities and/or archaeological salvage. Five prehistoric and 30 historic sites are also known to exist within the Management Area, but above pool elevation. Planning of recreational or management facilities in this zone would consider these sites.

The effects on cultural resources due to flood control storage at Big River Reservoir would not be significant.

At the next stage of project planning, Advanced Engineering and Design (AE&D), a cultural resource survey would be performed. Goals of this survey would be to locate a statistically valid sample of archaeological resource locations within the project area, assessment of the eligibility of historic and archaeological resources for inclusion in the National Register of Historic Places, and recommendation of specific mitigation strategies for adverse project impacts upon resources determined to be eligible for the National Register.

One advantage for cultural mitigation in the case of Big River Reservoir would be the potential for utilizing a portion of the adjoining State-owned lands to relocate (when deemed applicable) and preserve significant resources now in the inundation area. Historical cemeteries, buildings, or artifacts could be arranged into a "Historical Park" -- one that would represent the history of the Big River Management Area. One possible location would be along the existing Nooseneck Hill Road, between Big River and Nooseneck River (Figure 2).

5.05 Recreation

Since taking the Big River Management Area lands out of private ownership in the mid 1960's, the State has allowed the area to be used for a variety of recreational purposes. The expansiveness and undeveloped nature of the area provide excellent opportunities (mostly utilized by local residents) of varying value for hunting, fishing, horseback riding, swimming, boating, motorcycling, hiking, and general enjoyment of the outdoors.

Recreational demand at the Big River site is only a small percentage of the total statewide demand. Consequently, the elimination of recreation at Big River would have, in most cases, minimal impact on the state as a whole.

For the local area, however, the elimination of some or all of the recreation which presently takes place at Big River would create negative impacts in some areas, particularly in the surrounding towns. There would be a shortage of recreation facilities along with increased demands on the existing facilities.

However, the recreational plans proposed under Option III would attempt to mitigate these impacts by alleviating shortages in the local area. Boating facilities would be provided at Zeke's Bridge, on the east shores of the impoundment, and also at Carr Pond. The addition of the camping sites at Harkney and Hungry Hills would slightly offset the shortage of camping facilities expected for the state by 1995. The elimination of the limited unauthorized camping activity which presently occurs at Big River would have no impact on camping in the local area.

Fishing would be permitted from boats on Carr Pond and on the reservoir. Assuming that the quality of fishing is the same as or superior to present fishing, many who fish the area now would continue to go there. Those who presently prefer the stream fishing may not, however, be satisfied by the lake fishing in the reservoir. These fishermen would tend to travel to other streams or rivers in the local area. Problems of overcrowding in these areas are not expected.

As approximately 2,000 acres managed by the Division of Fish and Wildlife would be open to hunters, most of the potential impacts on hunting would be mitigated. These impacts would include increased usage on other management areas and private hunting areas in the region. The area to be managed by the Division of Fish and Wildlife would satisfy most of the demand for the local area projected for 2020.

Swimming facilities would be provided at Zeke's Bridge, Phelps Pond, and Carr Pond. These facilities would not only satisfy future demand for the local area, but would also alleviate some of the shortage at the State level as well.

During construction and filling of Big River Reservoir, recreational access would be prohibited resulting in long-term impacts on recreation. Recreation demand would have to be absorbed by other facilities.

Construction of the dam and associated clearing activities would result in water quality impacts in the downstream area. Although this impact would be short-term, it could affect the quality of water for fishing and swimming in Flat River Reservoir.

Due to Rhode Island's high population density, most construction workers would probably live within commuting distance of Big River. Recreation demands during the construction period, therefore, would not be increased by a short-term increase in local population.

5.06 Terrestrial Ecosystem

Construction of Big River Reservoir would change the existing stream-wetland-forest ecosystem to one of standing water. At a proposed crest elevation of 302.5 feet above MSL, 570 acres of wetlands and 2,305 acres of forestland would be inundated. The remaining area of impact is open land; primarily a golf course, small yards and fields, and one area of sand dunes.

Creation of the Big River Reservoir would remove 3,240 acres of wildlife habitat which would result in a decrease in wildlife populations in the area. Displaced wildlife would attempt to relocate to areas outside the proposed reservoir. However, those species that move to new areas would survive only if the carrying capacity for that species has not been reached in this area. If the habitat is already at its carrying capacity for that species, the excess would continue searching for available habitat or die.

The removal and modification of habitat through reservoir construction would reduce the total carrying capacity of the area for many forest-dependent wildlife species. Total number of individuals would decline as their habitat declines. Removal of food and cover plants would cause shortages, therefore there would be a decline in some species of small mammals and birds. This, in turn, would reduce availability of prey items to animals at higher trophic levels.

The reservoir would be characterized by a large open body of water supporting few floating plants, a reservoir border vegetated by plants adapted to the unstable environment created by fluctuating water levels and islands vegetated by upland plant communities.

Clearing and construction activities would directly affect small mammals which occupy burrows, such as mice, voles, and shrews. Gray squirrels, flying squirrels, porcupines and other mammals which occupy trees may be killed during tree felling operations. This impact would be most severe during the breeding season when litters of these species would be in dens or burrows. Noise would cause some animals to leave the area temporarily.

Big River Reservoir would provide suitable resting and feeding habitat for waterfowl species such as scaup, common goldeneyes, buffleheads, and other diving ducks which prefer large bodies of water. The vegetation along the edge of the reservoir would provide food and cover for puddle ducks, wading birds and aquatic furbearers. Canada geese may find the area attractive and nest on the islands and peninsulas of the reservoir area. The value of the peripheral areas of the reservoir would be contingent on bank drop-off, stability of water levels, and management practices.

Most birds would flee the area and direct mortality would be minimal. In spring and early summer, however, many bird species would be resting in the trees and shrubs, in tree cavities or on the ground. If construction occurred during this period, mortality of eggs and young may be close to 100 percent. Nesting habitat would also be destroyed.

The creation of an open reservoir would add a different landscape component to this area of Rhode Island. The existing landscape pattern in the study area is similar to others in the region, and the development of a reservoir would provide a diversity in landscape.

As only three feet would be added to the height of the dam for flood control, effects on fish and wildlife resources in the reservoir area would be minor when compared to those associated with the creation of the reservoir itself. Clearing or additional cutting of vegetation for flood control storage should not be necessary, and there would be no loss of wetlands due to the additional flood control increment.

Construction noise associated with installation of pipelines in the Providence, Pawtuxet and Warren Rivers would disturb resident wildlife in those areas for only the duration of the construction activities. Vegetation in access areas may have to be cut and removed to allow equipment access to the pipeline sites. Any existing waterfowl nesting areas would be disturbed depending on the time of year the transmission lines are installed.

Option III has proposed maximum recreation development in Big River Reservoir. However, it is not known at this time who will operate and maintain the proposed reservoir, or what their policies concerning recreation would be. The ultimate decision on the kind of recreation, if any, that would be allowed in Big River remains with the Rhode Island General Assembly. Undoubtedly, various constraints would be placed on recreation in the project area to protect the reservoir water quality.

Rhode Island Law (Title 46, Chapter 14, Section 1) prohibits the discharge of refuse or other matter which may pollute a water supply source used for drinking purposes. Certain recreational activities such as swimming are also prohibited, however other activities such as boating and fishing are not prohibited. Studies have indicated that recreation does not have a significant impact on water quality, especially with modern water treatment systems. It is also in the interest of safety on a large lake to allow motors, as well as to insure that fishermen are able to fully utilize the potential of the fishery resource.

Development of additional shoreline recreation facilities, primarily at existing recreation areas, would be compatible with wildlife management and mitigation practices. Construction of the proposed camping areas on Hungry and Harkney Hills may conflict with mitigation practices depending on the type of management undertaken in these areas.

The recreation plan proposed under Option III would not incur any long-term adverse environmental impacts. Any effects would be associated with the construction of picnic areas, restroom facilities, and boat ramps and would be short-term in duration. Horseback and hiking trails would provide edge habitat for the many species of birds and small mammals in the area. Limited off-road vehicle use would minimize environmental impacts and conflicts with other recreational activities and fish and wildlife management.

The environmental impacts associated with the proposed terrestrial mitigation plan would constitute an overall improvement in wildlife habitat conditions in the reservoir watershed after project implementation.

The construction of subimpoundments would provide wetland habitat which would otherwise be open reservoir water. They would be a mixture of scrub/shrub wetland, forested wetland, and open water and would provide habitat for many species of waterfowl and aquatic furbearers. Construction of the dikes would incur short-term impacts, and would be similar to those impacts associated with other construction activities in the reservoir.

Proper management of the reservoir watershed would increase wildlife habitat carrying capacity and should improve wildlife oriented recreational facilities such as hunting, bird watching and hiking.

The agricultural and open lands would be kept open by burning or mowing to provide habitat for those species which utilize open land and edge habitat. Grading of sand and gravel areas would allow natural succession of native vegetation types which would increase species diversity and provide nesting, denning, or perching sites for many wildlife species.

Any impacts resulting from the above practices would be associated with construction of access ways to the sites and disturbance of resident species while equipment is working in the areas. These would, however, be short-term effects.

5.07 Aquatic Ecosystem

The proposed Big River Reservoir would be a relatively deep (maximum depth about 60 feet, average about 25 feet), oligotrophic impoundment characterized by a relatively shallow thermocline, low nutrient level, and comparatively high dissolved oxygen (DO) levels throughout the year. The DO in the hypolimnion is expected to be above 5 mg/l throughout the year which would be suitable for development of a cold-water fishery. The pH would be essentially the same as that currently found in the watershed streams, ranging from 5.5 to 6.5.

Beneficial hydrologic effects include increased water supply yields to the existing water supply system, relieving potentially excessive future demands on Scituate Reservoir, and providing flood control along the Pawtuxet River in Warwick, West Warwick and Cranston, Rhode Island.

Construction of the Big River Reservoir would result in reduced flows in the South Branch and main stem Pawtuxet Rivers, and in Flat River Reservoir. The minimum average downstream release would approximate the present mean annual 1 day low flow rate and 10 year frequency 7 day rate (7Q10) on the South Branch and main stem Pawtuxet Rivers. Maximum water supply demand at Big River would reduce average annual flows on the South Branch in the vicinity of the USGS gage by about 40 percent and on the main stem Pawtuxet by as much as 15 percent. Inflows to Flat River Reservoir would be reduced by about 43 percent. Again, with Big River operating for maximum water supply, the minimum downstream capability of Flat River Reservoir would be reduced from 40 to about 33 cfs. If the release is modified to zero in March, April, May, and June and 12 cfs in July, August, September and October, the impact would be reduced by about 50 percent resulting in a minimum downstream release capability at Flat River of 37 cfs.

The minimum average downstream 7Q10 release could affect various organisms' capability to assimilate waste discharges. There would be reduced DO levels along with elevated temperatures. Those species most tolerant under these changed conditions would survive. At normal flow conditions there would not be any significant impacts on the aquatic biota.

Flat River Reservoir is a warm-water, relatively eutrophic lake providing largemouth bass and northern pike habitat. The average decrease in inflows to this lake should not have a significant detrimental effect on these populations.

M tigation of downstream impacts would be studied once the specific operational configuration of the project is designed.

With no inter-basin diversions into the reservoir, and the project operated in system with Scituate for maximum dependable water supply, the average annual lake fluctuations could be 3 to 6 feet with maximum annual fluctuations from 15 to 20 feet. Normally, drawdowns would occur during the period of July through October with the most pronounced refill period occurring during the spring period of March through April. Normal drawdown of 3 to 6 feet would vary the lake area about 150 to 300 acres, respectively, with maximum fluctuations resulting in about 800 acres of change in lake area.

Reservoir fluctuations would limit some rooted plant and bottom growth development in the near shore areas. However, as annual fluctuations would only be from 3 to 6 feet during the summer months, the exposed herbaceous vegetation would provide food and cover for waterfowl and other aquatic species. Effects on fisheries productivity due to fluctuations would not be significant as drawdowns would occur after the spawning season, and the stocking program would ensure the maintenance of a cold-water fishery.

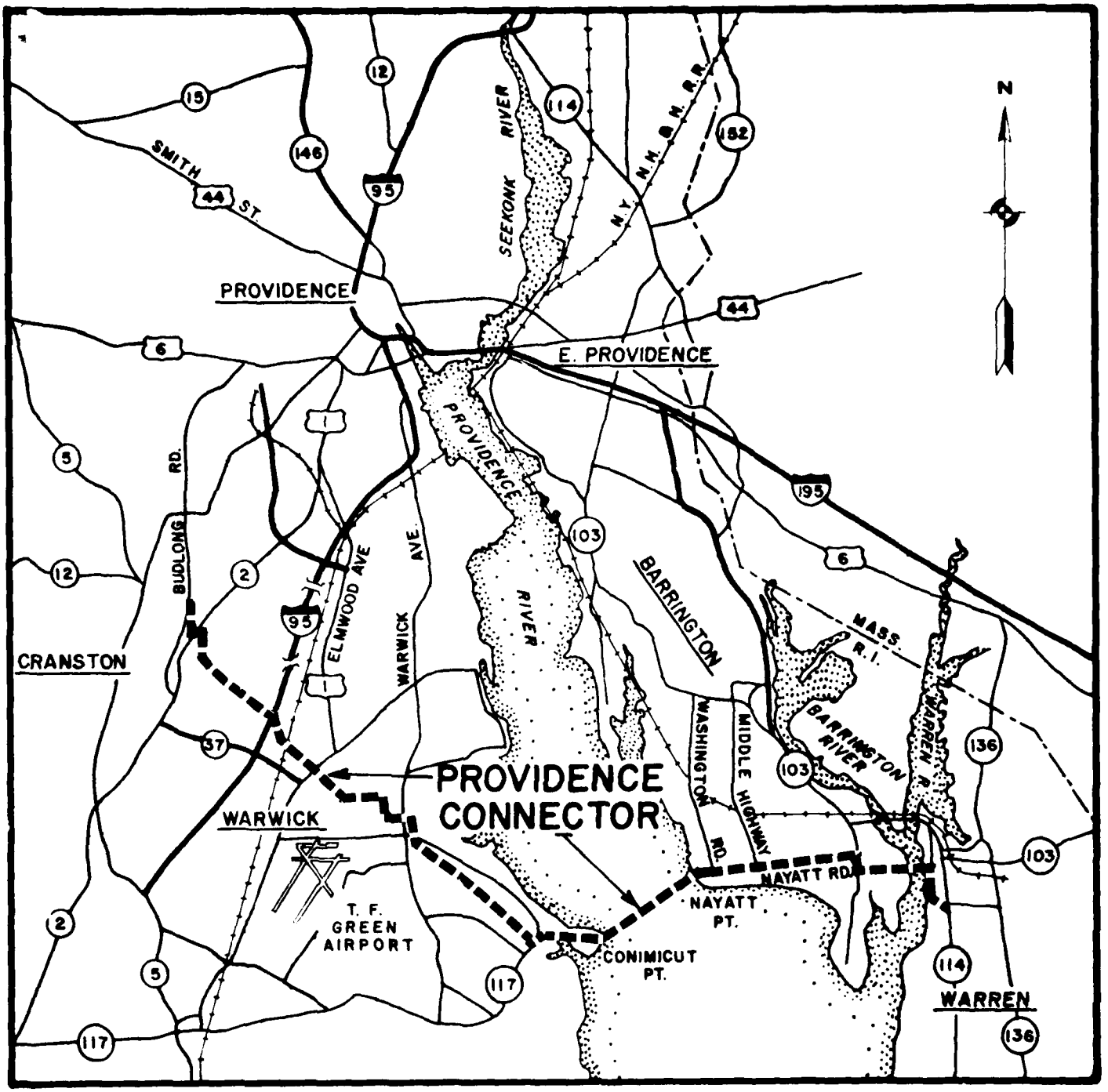
Big River Reservoir would inundate approximately 20 miles of cold- and warm-water streams. Capwell Mill, Tarbox, and several smaller ponds would also be inundated. Trout fishing in the streams, and warm-water fisheries in the ponds would be eliminated.

The reservoir would provide both a warm-water and cold-water fishery with the installation of multiple-level outlets. A trout fishery would be managed through a stocking program, and self-sustaining populations of sunfish, pickerel and perch would have an expanded habitat and offer a greater fishery potential than what existed before inundation. The reservoir would offer a more stable, higher quality sport fishery resource than the ponds and streams currently present within the proposed impoundment area. The yield of Big River Reservoir is expected to be similar to existing lakes and reservoirs in Rhode Island. Pre-impoundment stripping and grubbing of organic material from selected areas, and leaving trees, brush and boulders in others have been recommended which would maintain the fishery potential of the reservoir.

Primary productivity would increase during the first few years of impoundment as a result of enrichment by organic matter and associated nutrients contributed by inundation. Diversity and abundance of zooplankton and benthic macroinvertebrate populations would be at a maximum because of the abundance of food sources. However, over time, plankton and benthic communities would undergo a reduction in population, and the initial carrying capacities of aquatic biota attained during the first years of impoundment would be reduced to a new equilibrium. Species composition would also be altered and a new equilibrium established. This would include the elimination of species that could not adapt to the new environment and the introduction or proliferation of those species adaptable to new conditions.

Dam and reservoir construction operations and transmission facility construction would all produce localized short term impacts on the aquatic resources. The proposed alignment of the aqueduct to connect water supply for Big River to the existing system would be primarily through urban areas.

Crossings of the Pawtuxet, Providence and Warren Rivers (Figure 3) would result in short-term impacts on the aquatic ecosystem. Increases in turbidity, displacement and destruction of benthic organisms, disturbance of local fisheries, and increases in nutrient loading due to runoff from shoreline disturbances would occur during construction operations. The severity of these impacts would depend on the length of pipeline that would be installed. The crossing of the Providence River by an approximately 6,000 foot long pipeline between Conimicut Point in Warwick and Nayatt Point in Barrington would result in impacts of greater adversity than those that would be associated with the shorter crossings of the Pawtuxet and Warren Rivers.



LOCUS PLAN

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FIGURE 3

6.00 LIST OF PE

The following people were primarily responsible for contributions to this Environmental Impact Statement and A

Name	Professional Discipline	Education
John Craig	Civil Engineer, P.E.	B.S. Civil Engineering
B. E. Barrett	Ecologist	Ph.D. Zoology M.S. Zoology B.A. Zoology
Phillip Rieger	Ecologist	M.S. Zoology B.S. Biology/Chemistry/Geograph
Susan E. Brown	Biologist	B.S. Biology
Mark Desouza	Civil Engineer	B.S. Civil Engineering
John Barry	Economist	M.S. Candidate, Economics B.S. Political Science/Biology
John Wilson	Archaeologist	M.A. Anthropology B.A. Anthropology
Douglas Cleveland	Civil Engineer, P.E.	B.S. Civil Engineering
Diana Platt	Geographer	B.A. Geography
Robert Brustlin	Environmental Planner	M.L.A. (Masters Landscape Architecture) B.S. Civil Engineering B.A. Engineering Economics
David Coon	Fisheries Biologist	M.S. Fisheries Biology/Limnolog B.S. Biological Sciences
Michael Grubb	Wildlife Biologist	M.S. Wildlife Management B.S. Biological Sciences
Dennis Magee	Plant Ecologist	M.S. Forest Ecology B.S. Wildlife Biology
John Smith	Civil Engineer, P.E.	B.S. Civil Engineering
William McCarthy	Civil Engineer, P.E.	B.S. Civil Engineering

0 LIST OF PREPARERS AND CONTRIBUTORS

tement and Appendices:

tion	Experience	Contribution
ring	Sanitary Engineering Consulting, 12 years 5 years Waters Resources Planning, Planning Division, CE, 5 years	Project Manager
	Fisheries Research, 3 years; Fisheries Management, 3 years; Supervisor Environmental Studies, Planning Division, CE 6 years	EIS Project Manager
try/Geography	2.5 years Fisheries Research; Environmental Studies, Planning Division, CE 4 years	EIS Preparation and Coordination Staff
	Environmental Studies, Planning Division, CE 4 years	EIS Preparation and Coordination Staff
ring	Water Resources Planning, Planning Division, CE 3 years	Project Engineer - Technical Appendices
nomics nce/Biology	Regional Economist, Planning Division, CE, 3 years	Appendix J and EIS Preparation
	Staff Archaeologist, 1 year Archaeologist Consultant, 3 years Division Archaeologist, Planning Division, CE, 3 years	Appendix I and EIS Preparation
ring	Environmental and Recreational Resources Planning, Planning Division, CE, 12 years	Appendix H and EIS Preparation
	Geographer, Planning Division, CE, 4.5 years	Appendix K and EIS Preparation
dscape ring onomics	Project Manager for Various Engineering/Environmental Studies; Including Planning and Design of Various Recreation Facilities, 4 years	Technical Consultant - Appendix H
logy/Limnology ences	Environmental Impact Studies for Power Plants, Reservoirs, and Industrial Effluents on Aquatic Biota - 7 years	Technical Consultant - Appendix H
ement ences	Environmental Consulting - Impacts of Highway, Airport, and Reservoir Construction on Wildlife Populations - 4 years	Technical Consultant - Appendix H
gy	Consultant Addressing Impacts of Highways, Airport, Pipeline, and Building Construction on Fish and Wildlife Resources	Technical Consultant - Appendix H
ring	Water Resources Related Construction 5 years, CE; Resource Planning, 20 years, CE; Chief, Urban Studies Section, Planning Division	Policy Consultant
ring	Chief, Impact Analysis Branch, Planning Division, CE, 23 years	Policy Consultant

7.00 PUBLIC INVOLVEMENT

Four initial public meetings were held in May 1969 for the Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Study. These meetings were held in Taunton and Uxbridge, Massachusetts and Providence and Kingston, Rhode Island. The purpose of these meetings was to afford local interests the opportunity to express their needs and desires, to exchange information concerning the study, and to comment on some of the possible plans that could be considered. Subsequent to those meetings, numerous informal meetings were held with State and municipal interests and concerned citizens.

Two plan formulation public meetings were held on 6 and 8 May 1975 in Warwick and Cranston, Rhode Island, respectively. The purpose of these meetings was to present all of the alternative plans developed during the investigation and to incorporate public desires in plan formulation and choice of the most desirable alternative. Subsequent to these meetings nearly 100 field contacts were made, several informal meetings were held with citizens groups, approximately 20 informal contacts were made with State and municipal interests and nearly 50 informal contacts were made with Federal agencies.

The requested work items evolving from the public participation program were completed. A subsequent public meeting was held in Warwick on 14 October 1976 presenting the results of the study findings. Copies of the draft report and the Draft Environmental Impact Statement (EIS) prepared for the Pawtuxet River flood control study were distributed to the public prior to the meeting. Subsequent meetings held between October 1976 and May 1977 to determine the future course of action resulted in additional plans being offered for consideration. They were presented at another late stage public meeting held on 19 May 1977. Local flood management measures and study findings were discussed with Warwick and State officials on 3 March 1979, Warwick residents on 8 March 1979, and Cranston officials on 4 May 1979. A revised Selected Plan was subsequently developed.

Principal participants contacted during the progress of the Pawtuxet River Basin Study included the following:

Federal Agencies

U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
New England River Basins Commission

State Agencies

Rhode Island Water Resources Board
Statewide Planning Program
Department of Public Health
Department of Environmental Management
Historical Preservation Commission

Local Agencies/Organizations

City of Warwick
City of Cranston
Town of West Warwick

Although a Draft EIS was prepared for the Pawtuxet Study, further action on these documents was not carried out. The Report and Draft EIS have been combined in the Big River Reservoir study report.

A significant portion of the Corps' efforts in determining the scope of the feasibility and environmental studies pertaining to the Big River proposal also entailed solicitation of public concerns regarding the issues surrounding the proposed Big River Reservoir and related water resource needs and solutions in Rhode Island. The primary avenue of this effort was through public workshops. An initial four were held in September 1978, with another three in June 1979. These workshops were intended to acquaint public officials, interest groups, governmental bodies and other segments of the public with the Corps study -- general scope, methods of analysis, restrictions and tentative results -- and to obtain input to ensure that the scope of the study would, as comprehensively as justified, reflect the true public concerns surrounding any proposed measures.

In addition to the workshops, interviews with key State agencies and interest groups were conducted to highlight and bring additional insight into potential issues and concerns. These interviews were conducted with the following:

Organization	Contact
Audubon Society of Rhode Island	Alfred Hawkes
Ecology Action of Rhode Island	Bonnie Cimino/ Barry Schiller
Environmental Consultant	Dr. John Kupa
Kent County Water Authority	Norman St. Serveire
Natural Resources Group	Dr. Arthur Jeffrey
Office of the Governor	Anne Stubbs
Providence Dept. of Planning & Urban Development	John R. Kellam
Providence Water Supply Board	Peter J. Granieri
RI Dept. of Environmental Management	Calvin Dunwoody
RI Dept. of Health	John Hagopian
RI Federation of Riding Clubs	Joan Burgeault
RI Trail Advisory Group	Jack Deary/ Joan Burgeault
RI Water Resources Board	Peter Calise
RI Statewide Planning Program	J. Deary/V. Parmentier/ George Johnson
Town of Coventry	James Clarke
Town of East Greenwich	J. Burke/S. Deutch
Town of West Greenwich	Robert Maguire

Also, during the first workshop meetings, position papers and issue statements on Big River Reservoir issues were presented by representatives of the Providence Water Supply Board, the Rhode Island Office of State Planning, the Audubon Society of Rhode Island, the Town of West Greenwich, the Rhode Island Water Resource Board, the Federated Sportsman Club of Rhode Island, the Providence Department of Urban Development and the Office of the Governor. Refer to Appendix C "Public Participation" for a summarization of these papers and statements.

A Draft Feasibility Report, Draft Environmental Impact Statement, and a Draft Section "404" Evaluation with supporting appendices were distributed on 30 January 1981 for review by Federal, State, regional and local Government entities, interest groups and interested individuals.

A final public meeting was held on 26 March 1981 to present the Tentatively Recommended Plan and proposed Federal project to the public and to solicit views and comments on the Corps tentative recommendations.

The Final EIS and Final Report considers all comments received on the draft documents, and includes a recommended plan for fish and wildlife mitigation, and a Final "404" Evaluation. Comments and response on the draft document can be found in Appendix C, "Public Views and Responses."

TABLE 10

INDEX, REFERENCE AND APPENDIXES
BIG RIVER RESERVOIR

Subjects	STUDY DOCUMENTATION: Environmental Impact Statement	Main Report (References Incorporated)	Report Appendixes (References Incorporated)
Affected Environment	pp. EIS-27-30 para. 4.00	pp. 7-17	App. A, pp. A-12-A-33
Alternatives	pp. EIS-9-26 para. 3.00	pp. 52-64	App. B, pp. B-62-B-75
Areas of Controversy	pp. EIS-3-5 para. 1.02-1.03	pp. 3, 17-18	App. C
Comparative Impacts of Alternatives	pp. EIS-13-14, Table 3	pp. 65-66	App. B. pp. B-74-B-80
Cover Sheet	pp. i-ii	----------	----------
Environmental Conditions	pp. EIS-27-30 para. 4.00	pp. 7-17	App. H, Sections 2 & 3
Environmental Effects	pp. EIS-31-41 para. 5.00	pp. 54-55,59,62	App. B, pp. B-73-B-75
List of Preparers	pp. EIS-42 para. 6.00	----------	----------
Major Conclusions and Findings	pp. EIS-1-2 para. 1.01	pp. iii-v, 74-77	----------
Need for and Objectives of Action	pp. EIS-7-8 para. 2.00	pp. 7, 21-27	App. A, pp. A-44-A-55
Planning Objectives	pp. EIS-7 para. 2.02	pp. 27-29	App. A, pp. A-60-A-61
Plans Considered in Detail	pp. EIS-13-26 para. 3.03	pp. 52-64	App. B, pp. B-62-B-75, App. H, Sec 1
Plan Eliminated from Further Study	pp. EIS-9-12 para. 3.01	pp. 40-51	App. B, pp. B-38-B-47, B-51-B-54
Public Concerns	pp. EIS-7-8 para. 2.03	pp. 2-3, 21-27	App. C
Public Involvement	pp. EIS-43-45 para. 7.00	pp. 2-3	App. C. pp. C-1-C-5
Public Involvement Program	pp. EIS 43-45 para. 7.00	pp. 2-3	App. C
Public Views and Responses	pp. EIS-45 para. 7.00	pp. 58,61,64	App. C
Relationship to Environmental Requirements	pp. EIS-5-6 para. 1.04	pp. 7, 27-29	App. H, Sec. 1,2, & 3, App. I Sec. 2
Required Coordination	pp. EIS-5-6 para. 1.04	----------	----------
RESOURCES:			
Aesthetics	pp. EIS-33-34 para. 5.03	pp. 8-9, 14,17	----------
Aquatic Resources	pp. EIS-39-41 para. 5.07	pp. 8-12	App. H, Section 2
Cultural Resources	pp. EIS-34-35 para. 5.04	p. 17	App. I, Section 2
Demography	pp. EIS-31 para. 5.02.1	pp. 13-16	App. A, pp. A-25, A-35-A-38
Economics	pp. EIS-31-32 para. 5.02.2	pp. 13-16	App. A, pp. A-25-A-31
Mitigation	pp. EIS-18-26 para. 3.03.6, EIS-38-39 para. 5.06	pp. 56	App. H, Section 4
Recreation	pp. EIS-35-36 para. 5.05	p. 16	App. H, Section 1
Terrestrial Resources	pp. EIS-36-39 para. 5.06	pp. 9-10, 12-13	App. H, Section 3
Transportation	pp. EIS-33 para. 5.02.3	pp. 15-16	App. A, pp. A-31-A-32
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Statement Recipients	----------	----------	App. C
Study Authority	pp. EIS-7 para. 2.01	p. 1	App. A, pp. A-1-A-2
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Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

THE CLEAN WATER ACT

SECTION 404 EVALUATION

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

This report is intended to provide an evaluation of the proposed Big River water supply/flood control project in central Rhode Island. This evaluation is in conformance with Section 404 of the Federal Water Pollution Control Act of 1972, amended as the Clean Water Act, December 27,1977.

Application and administration of the 404 requirements are assigned to the administrator of the Environmental Protection Agency (EPA) and the Secretary of the Army. Guidelines for the evaluation were published by the EPA in the Federal Register, September 5, 1975 (40 CFR 230, hereinafter refered to as the guidelines). Pursuant to a recent Corps of Engineers regulation (ER 1105-2-90, dated October 10, 1978), the guidelines are to be applied in evaluation of all Corps of Engineers activities involving discharge of dredged or fill material in navigable waters.* Any impacts to the specific items addressed by the guidelines that would presumably result from construction of the dam are addressed in this report.

The purpose of the Act is to provide a means of protecting vital water resources from despoliation through irresponsible and irreversible decisions and actions. This evaluation provides or references information sufficient to determine whether unacceptable or unnecessary degradation of such values would result from project implementation.

The guidelines are particularly applicable in relation to wetlands, water supply, fish and wildlife resources, and recreational values. The intent of the guidelines is to require an ecological evaluation of such aspects (Section 230.4) and pertinent consideration and conditioning of the discharge (Section 230.5) to minimize or prevent unnecessary degradation of aquatic resources. Corps of Engineers regulations (ER 1105-2-90) specifies that evaluation analysis and findings shall be presented so that reviewers may clearly find each of the points listed in Section 230.4(1) Chapter IV is intended to fulfill this requisite.

Because of the structured technical nature of this evaluation, Chapters IV, V and VI can best be comprehended by familiarity with the guidelines. Chapter III, however, summarizes in a less specific and technical nature the more significant relevant impacts. Related information is also available in the Big River Reservoir Environmental Impact Statement (EIS), the Feasibility Report, and associated appendices, particularly in Appendix D, "Hydrologic Analysis," Appendix E, "Water Quality" and Appendix H, "Recreation and Natural Resources." Reference to these publications may be desirable to fully understand certain conclusions regarding impacts only superficially discussed in this evaluation.

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*See Glossary for definitions per EPA guidelines.

CHAPTER II

DESCRIPTION OF PROPOSED PROJECT AND ITS SETTING

The proposed 3400 acre multi-purpose (combined water supply, recreation, and flood control) reservoir would be located in the Big River Basin, a tributary to the South Branch of the Pawtuxet River, Rhode Island. The installation would consist of a 70 foot high dam to elevation 312 NGVD located at the confluence of the Big River with Flat River Reservoir (Figure 1). The 2315 acres of forests within the reservoir site would be cleared prior to impoundment to elevation 303.0 NGVD. (Maximum pool level). This includes 3 feet for 9,500 acre feet of flood control storage; an equivalent to 6 inches of run-off from the 29.7 square mile watershed.

Approximately 7 miles of underground aqueduct would transfer the reservoir water to the existing City of Providence water supply system.

The watershed upstream of the proposed Big River Dam is of relatively mild topographic relief, with broad poorly drained swampy valleys. This area is within one of the largest relatively uninhabited areas in the State of Rhode Island. The existing character of the region has resulted from State ownership since 1965 of about 8,300 acres of land, known as the Big River Management Area. The area was purchased by eminent domain to protect the reservoir site from development which would be incompatible with the proposed project purpose. Existing use of the area consists primarily of informal recreational activities such as hunting, fishing, motorcycling, and horseback riding. Although the presence of a water supply reservoir would preclude the area being considered for all recreation uses with the project, it has the potential for providing compatible recreation under proper management. A more detailed description of the project, its setting, impacts, and various alternatives to the project and alternatives within the project is provided in the Main Report and EIS.

CHAPTER III

EVALUATION SUMMARY

The most obvious and direct impact of the proposed Big River Reservoir on the environment would be the irreversible transformation of an existing 3240 acre stream-forest ecosystem to one of standing water. Some 19.7 miles of stream habitat (54.5% of the 36.2 miles in the Big River Basin) and at least 10 small ponds totalling about 45 acres would be inundated; 3154 acres of terrestrial habitat including 2305 acres of forest, and 570 acres of wetlands and 325 acres of open land would be lost.

These components of the existing ecosystem would be replaced by the 3240 acre Big River Reservoir. As a consequence, various fish and wildlife, aesthetic, and recreation values would be affected. Appendix H, "Recreation and Natural Resources" contains information regarding these values. The conversion of terrestrial habitat into aquatic habitat would displace wildlife species which utilize the resources within the proposed area for inundation. Wildlife in adjacent regions would be affected through crowding by increased immigration of those animals utilizing the habitat that would be impounded.

In the southern portion of the reservoir watershed bordered by the New London Turnpike approximately 2,000 acres of upland habitat would be available for intensive wildlife management. The area would have limited access and would be used for recreational purposes. This area would also be managed for small game, deer and waterfowl hunting with access provided on a seasonal basis. The remaining 2,000 acres would also be managed for wildlife, however, only to an extent that would be compatible with the recreational use proposed for the area. Management in these areas would emphasize improving habitat for those wildlife species pleasing to people (songbirds, etc.). The area north of I-95 would be managed as a wildlife sanctuary.

In addition to upland resources lost by inundation, many acres of wetland and riparian habitats would be lost. Representing about 17% of the area that would be inundated, wetland losses should be considered as a significant impact due in part to the relative scarcity in the State (1.5% of the total land area), and to their important contribution to the overall biological productivity and diversity of a region. Section 230.4-1 is devoted primarily to consideration of wetlands;* and the Corps' proposed fish and wildlife mitigation plan includes mitigation of wetland losses. The plan proposes construction of 3 subimpoundments which would stabilize water levels and allow aquatic plants to establish. If properly constructed and managed, these areas would become very attractive wildlife habitats, important to many of the species presently utilizing the proposed inundation area.

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*See Glossary for definition.

The existing stream fishery would be replaced by a lake fishery. A total of 15 fish species, including sports fish such as brook trout, largemouth bass, and pickerel, inhabit the streams and ponds in the project area.

The headwaters of most of the streams support native brook trout. The remaining portions of the streams support both cold-water and warm-water species. The larger streams, such as Big River and Nooseneck, are stocked annually with trout. Warm-water species are self-sustaining and not intensively managed.

After the reservoir is filled, the warm-water species already present in the system would reproduce and grow at a greater than normal rate, and will level off when the carrying capacity of the reservoir is reached. Largemouth bass, chain pickerel, yellow perch, brown bullhead, and sunfish would be present. Because of the nutrient availability and rapid growth of the existing populations, a warm-water species stocking program should not be necessary. The physical characteristics of the reservoir would be suitable for the introduction of smallmouth bass. A cold-water fishery would be established through a trout stocking program.

Project implementation would create a significant change in recreational use of the region. In addition to alteration of fishing and hunting opportunities, areas of horseback riding, motorcycling, hiking, and other activities would be displaced by the reservoir. However, recreational opportunities based on the lake environment have been recommended which would replace those types of recreation in many areas (Appendix H, "Recreation and Natural Resources").

Short-term construction and operational off-site effects would occur, and include: downstream sedimentation during construction and a modified downstream flow regime creating biological stresses on downstream biota. Efforts would be made to minimize undesirable degradation where possible.

CHAPTER IV

SECTION 230.4-1

ECOLOGICAL EVALUATION

230.4-1(A) PHYSICAL EFFECTS

Physical effects on the aquatic environment include destruction of wetlands, impairment of the water column, and covering of benthic* communities. Evaluation of the significance of such effects is based primarily on the extent of the discharge area and related environmental elements displaced or affected by the proposed discharge. Following is a short explanation of how such physical effects relate to the Big River Reservoir Project as specified in the guidelines.

230.4-1(A-1) Effects on Wetlands: The guidelines of the Clean Water Act regards the degradation or destruction of wetlands as the most qualitatively significant type of environmental impact: "Destruction of wetlands is an irreversible loss of invaluable aquatic resources."

The implied categorical significance of wetland destruction is primarily related to the value of wetlands as a function toward the ecological integrity of a region. Wetlands function, as specified in the guidelines, would apply to Big River Reservoir project are as follows:

(i) "Wetlands that serve important natural biological functions, including food chain production, general habitat and nesting, spawning, rearing and resting sites for aquatic or land species..."

Many such wetlands exist within the proposed area. The proposed mitigation plan utilizes the value of these wetlands for certain wildlife species as a guide to provide, through construction of subimpoundments, the types of wetland habitat (within site limitations) of most value to the ecosystem with the project.

(ii) "Wetlands set aside for the study of the aquatic environment or as sanctuaries or refuges..."

No such areas are found within the project area.

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* See Glossary.

(iii) "Wetlands contiguous to areas listed in (A)(i) and (ii) this section, the destruction of which would effect detrimentally the natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics of the above area..."

The (A)(i) areas would no longer exist, and (A) (ii) are not found in the watershed or downstream of the project.

(iv) "Wetlands that are significant in shielding other areas from wave action, erosion or storm damage. Such wetlands often include beaches, islands, reefs, and bars..."

The magnitude of hydrologic effects of the reservoir itself should be considered as replacement for any loss of this kind. The reservoir would displace wetlands but would provide much greater shielding against erosion, flooding, etc.

(v) "Wetlands that serve as valuable storage areas for storm and flood waters..."

The flood storage capability of the reservoir would compensate any loss of this function.

(vi) "Wetlands that are prime natural recharge areas... where surface and groundwater are directly interconnected..."

Again, the recharge potential of the reservoir would compensate for such losses.

In summary, the ecological significance of wetland losses due to project implementation would primarily relate to biological (A-1)(i) functions. It is the objective of management strategies and modification structures to mitigate for such lost biological functions.

230.4-1(A-2) Effects on the Water Column: The existing stream-wetland-forest ecosystem would be transformed to one of standing water About 10 small ponds and 19.7 miles of intermittent and continuous streams would be inundated. The two largest ponds, Tarbox pond (17.5 acres) and Capwell Mill Pond (11.7 acres), with average depths of about 3.5 feet, provide a limited warm-water fishery and the adjacent wetlands provide habitat for various waterfowl and other wildlife. Specific physical changes include: A lowered temperature regime; a "sink affect" on incoming suspended sediments; and a shift in planktonic* populations from lotic to lentic species. Also, the downstream water column would be affected by increased suspended sediment and nutrient loads during the construction period.

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*See Glossary.

230.4-1(A-3) Effects on Benthos: Existing stream species within the impoundment area would be replaced by lake species. Construction-related and operational stresses on the downstream benthic communities are expected.

230.4-1(B)

CHEMICAL-BIOLOGICAL INTERACTIVE EFFECTS

Chemical-biological interactive effects would result from release of contaminants from the inundated soils, particularly those soils disturbed during clearing activities and dam construction. The principal 404 concern is the potential effect on benthic and fish communities. Clearing activities would in the long term be beneficial to the ecosystem by allowing the reservoir to become more oligotrophic* through removal of much of the organic material within the site. This not only allows better quality drinking water, but would provide a habitat more suitable for desirable fish species such as trout and smallmouth bass which have all but disappeared from Rhode Island waters due to eutrophication.*

230.4-1(B-1) Evaluation of the Potential of Chemical-Biological Interactive Effects: Potentially detrimental chemical constituents that may be present in existing soils in sufficient quantities to leach into and affect lake or downstream waters include nutrients and organic material. The potential of such contamination is discussed in the following subsections.

230.4-1(B-2) Water Column Effects: The procedures proposed by the EPA in the guidelines to predict water column effects, although suitable for the effects of dredged material disposal, are not appropriate in reservoir analysis. However, qualitative conclusions as to water quality effects can be made based on past studies, samples in the project area, and appropriate analytical techniques.

Analysis of water quality data collected throughout the Big River watershed (Appendix E, "Water Quality") indicate that such potential pollutants as organic material, nutrients, coliform bacteria, turbidity, pesticides, chlorides, and heavy metals such as iron and manganese will not be present in the reservoir in concentrations harmful to aquatic life. Iron and manganese, however, are estimated to possibly exceed national drinking water regulations (300 and 50 micrograms per liter, respectively) during the initial stabilization of the reservoir (10-20 years). Appropriate water treatment would be provided at the treatment plant as necessary. The water quality of Big River Reservoir is predicted to be as good as or better than Scituate Reservoir, which is the existing reservoir for the Providence water supply. This water is regarded by many as among the finest natural quality in the country.

*See Glossary.

Other water quality parameters such as color, pH, dissolved oxygen, and temperature are predicted to be variable with seasonal conditions, but favorable for aquatic life. The chemical and physical aspects of Big River Reservoir would support salmonid fish species -- a factor that is generally indicative of a "high quality" aquatic resource. The reservoir would limnologically* be classified as oligotrophic.**

During the clearing-construction-filling period, low flows and higher temperatures combined with higher quantities of nutrients may create algal blooms in downstream areas, particularly in Flat River Reservoir. However, this reservoir is already relatively eutrophic** due in large part to the highly residential watershed and resulting nutrient loading. The increase of organic material from either algal blooms, or directly introduced with erosion may increase the biological oxygen demand (BOD)* enough to create greater oxygen deficient conditions in portions of Flat River Reservoir. Advanced engineering studies would further investigate and identify downstream mitigation measures once the specific operational configuration of the project is designed. Although it could have no noticeable effect, the probability for a detrimental effect in a small area is high. Control conditions would be established and coordinated with the State to lessen the possibility of the latter situation. When the assumed Big River Reservoir Operation (Appendix D, "Hydrologic Analysis") is superimposed onto the Upper Pawtuxet Basin, there is a marked effect on the hydrology of Flat River Reservoir and the South Branch of the Pawtuxet River. By reducing the natural average flow into Flat River Reservoir by about 43%, the average minimum downstream yield of Flat River Reservoir as augmentation to the Pawtuxet River would be reduced from about 40 to 33 cfs with existing operational policy of Flat River Reservoir continuing. However, if modification to the existing Flat River operation were implemented in light of the impact and the augmentation potential of Big River Reservoir, this average minimum release could be maintained at about 37 cfs. Plate 15 in Appendix D simulates this effect.

Under these conditions, the water levels in Flat River Reservoir would also be impacted and drawdowns would be more frequent and of greater duration and magnitude. A plot comparing pool levels of Flat River Reservoir with and without Big River Reservoir is also shown on Plate 15, in Appendix D.

230.4-1(B-3) Effects on Benthos: Concentrations of contaminants are not expected to be sufficient to impair benthic productivity.

230.4-1(C) Comparison of Sites

Not applicable to this evaluation as it applies to disposal of dredged material.*

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*See Glossary.

**A characterization of oligotrophic and eutrophic lakes is provided on page 23 following the glossary.

CHAPTER V

SECTION 230.4-2

WATER QUALITY CONSIDERATIONS

Creation of the Big River impoundment would preclude existing water quality standards for streams within the impounded areas; such standards would be inappropriate for a reservoir. The predicted water quality of the reservoirs is explained in more detail in the EIS, and in Section 4-1(B-2) of this evaluation. The results of water quality predictions (Appendix E, "Water Quality") indicate that the reservoir should present no water quality problems. The lake is predicted to be a relatively deep, oligotrophic impoundment characterized by a relatively shallow thermocline, low nutrient levels, and comparatively high dissolved oxygen levels throughout the year. The lake water quality should be better than existing conditions. The State of Rhode Island would establish reservoir water quality standards and monitoring provisions with the intent of providing quality drinking water to the Providence metropolitan area water supply system.

Downstream water quality considerations are necessary. The "mixing zone" as described in the guidelines, Section 230.5(E), as applicable to such considerations would include part of Flat River Reservoir downstream to Narragansett Bay via the South Branch of the Pawtuxet River (See Figure 1, EIS). The altered flow regime from the impoundment may effect the assimilation of pollutants in the Pawtuxet River. As recommended in the Rhode Island 208 Water Quality Management Plan, a 10 year 7 day low flow (7Q10) would be required in the South Branch of the Pawtuxet below Flat River Reservoir to ensure predicted assimilation of the various pollutant loadings along the river. The augmentation potential of Big River Reservoir could be utilized to maintain this low flow.

Chemical constituents presented in Section 230.4(B-1) that would influence long-term water quality within the reservoir, and possibly downstream, are predicted to be low. Short-term water quality impacts would relate physically to the turbidity and sedimentation caused by erosion from dam construction and site preparation activities. During construction, increased releases of chemical contaminants would accompany erosion to the river. Because of the potential of erosion related impacts, extensive erosion and siltation control methods would be required. These methods would employ clearing, excavation, and grading practices; diversions, disposal and land stabilization structures; and vegetation control measures. In spite of these methods, siltation to some degree would unavoidably occur during periods of heavy rainfall. Control measures would lessen such effects with the intent of not degrading downstream water quality conditions at levels unacceptably greater than natural conditions.

CHAPTER VI

SECTION 230.5

SELECTION OF DISPOSAL SITE AND THE CONDITIONING OF DISCHARGE OF DREDGE OR FILL MATERIAL

230.5(A) GENERAL CONSIDERATIONS AND OBJECTIVES

The following impacts (outlined in conformance with the guidelines, Section 230.5(A)) would result from implementation of the proposed Big River Reservoir project. They have been considered in the determination of recommendations regarding the proposed project under the authority of these guidelines:

(1) Significant disruption of the chemical, physical and biological integrity of the aquatic ecosystem, including the aquatic biota and substrate would occur;

(2) Significant disruption of the food chain, including alteration or decrease in diversity of terrestrial plant and animal species within the impoundment area would occur;

(3) Inhibition of movement of fauna, including movement into and out of feeding, spawning, breeding, and nursery areas would occur;

(4) The wetlands of the area do not have significant functions in maintenance of water quality;

(5) The impoundment would inundate areas presently retaining natural high or flood waters, but the reservoir itself would provide more flood control than presently exists;

(6) Adverse turbidity levels would result from construction activities;

(7) Existing aesthetic, recreational and economic values would be displaced; and

(8) As was indicated in Section 230.4, water quality degradation during construction and filling, would result. The quality of water leaving the watershed would be better than existing conditions.

According to the guidelines: "In evaluating whether to permit a proposed discharge of dredge or fill material into navigable waters, consideration shall be given to the need for the proposed activity, the availability of alternative sites and methods of disposal that are less damaging to the environment, and such water quality standards as are appropriate and applicable by law."

In planning the Big River Reservoir facility, many water supply and flood control alternatives were considered. Alternatives such as other surface reservoir sites, existing reservoirs, groundwater, demand modification, sea water desalination, and structural and non-structural site flood control alternatives are addressed in the Big River EIS and Feasibility Report. The decision factors included:

(1) Other surface water storage sites include impoundments in the Flat River, Wood River, Moosup River, and Buck's Horn Brook. All of these would involve intra-basin water transfer. All would impact better, and more heavily utilized stream habitats. None offer the desirable flood damage prevention to the towns of West Warwick, Warwick, and Cranston along the mainstem of the Pawtuxet River, or as much water supply yield as is possible with the Big River site.

(2) Various existing reservoir sites could be tapped into a combination of new transmission and treatment facilities (Appendix B, "Plan Formulation"). However, all of these reservoirs already have purposes deemed incompatible to water supply: recreation, industry, residential, etc. State law* precludes such activities as bathing and dumping refuse into a public water supply. Recreation would not be allowed, nearby residents would have to be relocated, and several industrial uses would be precluded; or, the State law would have to be changed and more expensive water treatment would be required as a result of the lower quality water available in such existing sites. Again, no flood control to the Pawtuxet River would be offered.

(3) Untapped groundwater reserves are available for use in the demand area. This resource could be utilized to supplement the water supply system, however, it does not satisfy the predicted need.

(4) Weather modification, although a potential water supply measure, is not technically reliable and the potential environmental impacts are not fully understood.

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*See Appendix H, "Recreation and Natural Resources."

(5) Demand modification would, if implemented, curtail up to about 11 percent of the predicted need.

(6) Sea water desalination is an almost unlimited supply source, however, the non-renewable energy costs involved with all methods of this process when weighed against the low cost of a natural storage site have made this alternative economically impractical in an area with adequate rainfall.

230.5(B) Considerations Relating to Degradation of Water Uses at Proposed Disposal Site

Some existing water uses would be affected through implementation of the Big River Reservoir project. Consideration of such values is summarized in accordance with the guidelines as follows:

(1) Municipal Water Supply Intakes - No known public water supplies would be adversely effected by Big River Reservoir. The Providence water supply would be augmented by the reservoir.

(2) Shellfish - No areas of important shellfish populations would be affected.

(3) Fisheries - The Big River project would completely change the existing fishery habitat. This change is discussed in more detail in the EIS and Appendix H, "Recreation and Natural Resources." The change is not regarded as unacceptable because the lake fishery afforded by the project is predicted to be better than the existing fishery resource.

(4) Wildlife - The habitat, food chain and community structure of existing wildlife within and nearby the proposed impoundment would be affected. The EIS and Appendix H, "Recreation and Natural Resources" discusses this aspect in detail.

(5) Recreation Activities - Appendix H discusses recreational impacts in detail. In relation to this evaluation, concerned factors apply as follows:

(i) Reasonable methods to minimize adverse turbidity would be employed (See Section 230.4-2);

(ii) The release of nutrients during construction is not expected to increase downstream eutrophication, and degrade aesthetic values. It may, however, impair recreation uses of a small portion of Flat River Reservoir (See Section 230.4(B-2);

(iii) No material that would result in unacceptable levels of pathogenic organisms would be discharged in areas to be used for recreation;

(iv) No material would be discharged which would result in release of oil or grease in harmful quantities.

(6) Threatened and Endangered Species - The various studies in Appendix H, "Recreation and Natural Resources" have not indicated that any endangered species or habitats would be adversely affected by the proposed action.

(7) Benthic Life - Existing benthic communities within the impounded areas would be displaced and a new benthic habitat would result and allow new community structures to become established. Also, benthic life directly below the impoundment would be stressed during construction related sedimentation and benthic diversity would be reduced.

(8) Wetlands - The effects of Big River Reservoir on wetlands were discussed in Section 230.4-1 and in the EIS. The primary detrimental impact on this project on wetlands is related to biological systems. Wetland impacts, according to the guidelines, may be permitted if:

"(a) the activity associated with the fill must have direct access or proximity to, or be located in, the water resource in order to fulfill its basic purpose, or that other site or construction alternatives are not practicable; and (b) that the proposed fill and the activity associated with it will not cause a permanent unacceptable disruption to the beneficial water quality uses of the affected ecosystem, or that the discharge is part of an approved Federal program which will protect or enhance the value of the wetlands to the ecosystem."

An examination of these factors as related to the proposed Big River Reservoir allows determination that the project is permitted through these requirements:

(1) Dam construction ("the activity associated with the fill") must be located in the water resource in order to create an impoundment for the basic purpose of water storage;

(2) Other sites to provide the same purpose has been considered and determined as not practicable (Appendix B, "Plan Formulation").

(3) Construction alternatives to provide mitigation of unpreventable wetland losses have been proposed; and

(4) The major beneficial water quality use of the affected ecosystem include primarily a limited fishery. The reservoir would create a more beneficial water quality use -- water supply to a large Rhode Island metropolitan area and an improved fishery.

9. Submerged Vegetation - Many wetlands contain submerged vegetation. Such areas within the project area and the significance of biological productivity can be derived from Appendix H, "Recreation and Natural Resources."

10. Size of Disposal Site - In consideration of alternative reservoir sizes and sites, water resource impacts would be qualitatively similar or less at the Big River site. The selected level and site for the Big River Dam was based on optimization of economic and water supply potential of the environment. Reduction of the size of the reservoir to a degree sufficient to realize meanful environmental advantages would also defer feasibility of the site. Such a reduction would mostly create the need for other alternative water supply sources.

230.5(C) Applicable Considerations In Determining the Site and Disposal Conditions To Minimize the Possibility of Harmful Effects

1. Appropriate scientific literature has been consulted for all aspects of the project to locate, investigate, describe, and propose mitigation measures for impacts to fisheries, wildlife, wetlands, downstream water quality and reservoir management;

2. Alternatives to the method of inundation do not exist;

3. Not Applicable - Refers to disposal of wastewater;

4. Not Applicable - Refers to open disposal of waste material;

5. Not Applicable - Refers to covering contaminated waste material;

6. Conditions to minimize the effect of runoff from construction areas have been considered; and

7. Conditions would be established as necessary to control and minimize water quality degradation (see Section 230.4-2).

230.5(D) Contaminated Fill Material Restrictions

The material that would be discharged is not expected to contain unacceptable quantities, concentrations or forms of the constituents deemed potentially critical by the analysis presented in Section 230.4.

230.5(E) Mixing Zone Determination

Methods specified in the guidelines to be used in determining the mixing zone are only vaguely appropriate to show dispersion of the constituents for discharged material in this project. The area of inundation was determined by other analytical methods. The downstream mixing zone of constituents identified in Section 230.4-2, is related to factors outlined in the guidelines as follows:

(1) Surface area, shape and volume of the discharge site;

(2) Current velocity, direction and consistency at the discharge site;

(3) Degree of turbulence;

(4) Stratification attributable to causes which include, but are not limited to, salinity, obstructions and specific gravity;

(5) Any on-site studies or mathematical models which have been developed with respect to mixing patterns at the discharge site; and,

(6) *Other factors* prevailing at the discharge site that affect rates and patterns of mixing.

Consideration of all such factors indicate that the construction of the Big River Reservoir would affect water resources a considerable distance downstream (i.e., to Narragansett Bay) in some manner. Item (6) above is, however, the most appropriate consideration in this instance. Although some effects of the reservoir would occur in the Pawtuxet River (flood control and flow augmentation) the contiguous area of Flat River Reservoir would be the downstream area where ecological effects would be most noticeable. This area and the potential impacts are discussed in the EIS.

CHAPTER VII

CONCLUSION

It is my opinion, through review of this evaluation, that the water resource concerns outlined by the EPA 404 Guidelines (40 CFR 230) have been clearly identified and presented to allow the determination required by Section 230.3(a) of the Clean Water Act. In accordance with this requirement, I have made the following conclusions:

1. Every attempt has been made to provide for, with pertinent consideration of physical laws and known ecological phenomenon, reasonable minimization and/or mitigation for adverse environmental impacts.

2. Consideration has been given to the need for the project, the availability of alternative sites and methods of disposal that are less damaging to the environment, and such water quality standards as are appropriate and applicable by law.

3. The activity associated with the fill (dam construction) must be located in the water resource to provide its basic purpose (impounding water).

4. No unacceptable disruptions to existing beneficial water quality uses would result for the proposed project.

I therefore conclude that the Big River Reservoir Project can be specified through application of the Clean Water Act of 1977.

29 June 81
Date

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

GLOSSARY

The following terms are defined in the perspective of this evaluation.

Benthic. Of, relating to, or occurring at the bottom of a body of water.

Biological Oxygen Demand. The oxygen used in meeting the needs of aerobic microorganisms in water rich in organic matter.

Constituents*. Chemical substances, solids, and organisms associated with dredged or fill material.

Contaminant. Something that, when introduced into an environment, creates undesirable reactions.

Discharge of Fill Material*. The addition of fill material into navigable waters for the purposes of creating impoundments of water. The term generally includes dams and dikes.

Dredged Material*. Material that is excavated or dredged from navigable waters.

Eutrophic**. Rich in nutritive matter.

Fill Material*. Any pollutant used to create fill in the sense of replacing an aquatic area with dry land or of changing the bottom elevation of a body of water for any purpose.

Limnology. The study of fresh water.

Mitigate. To cause to become less harsh or hostile; to make less severe or painful; alleviate.

Navigable Waters*. Generally, up to the high water mark of any U.S. waters greater than 5 cfs average flow, and any water resources contiguous to such waters including, but not restricted to, lakes, ponds, wetlands, and intermittent streams.

Oligotrophic**. Poor in nutritive matter.

Plankton. The passively floating or swimming, usually minute animal and plant life, of a body of water.

Riparian. Related to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Wetlands*. Those areas that are periodically inundated and that are normally characterized by the prevalence of vegetation that requires saturated soil conditions for growth and reproduction.

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*Definitions from 40 CFR 230 (EPA Guidelines App. A).

**These terms are used to categorize and compare Big River Reservoir and Flat River Reservoir. A summary of some of the more important characterization according to Welch, 1952 of each category is provided on the last page of this evaluation.

Characterization Summary (Welch, 1952)* of Oligotrophic and Eutrophic Lakes

1. Oligotrophic lakes:

   a. Very deep; thermocline high; volume of hypolimnion large; water of hypolimnion cold.
   b. Organic materials on bottom and in suspension very low.
   c. Electrolytes low, or variable; calcium, phosphorus, and nitrogen relatively poor; humic materials very low or absent.
   d. Dissolved oxygen content high at all depths and throughout the year.
   e. Larger aquatic plants scanty.
   f. Plankton quantitatively restricted; species many; water blooms rare; Chlorophyceae dominant.
   g. Profundal fauna relatively rich in species and quantity.
   h. Deep-dwelling, cold-water fishes (salmon, cisco, trout), common to abundant.
   i. Succession into eutrophic type.

2. Eutrophic lakes:

   a. Relatively shallow; deep, cold water minimal or absent.
   b. Organic materials on bottom and in suspension abundant.
   c. Electrolytes variable, often high; calcium, phosphorus, and nitrogen abundant; humic materials slight.
   d. Dissolved oxygen, in deeper stratified lakes of this type, minimal or absent in hypolimnion.
   e. Larger aquatic plants abundant.
   f. Plankton quantitatively abundant; quality variable; water blooms common; Myxophyceae and diatoms predominant.
   g. Profundal fauna, in deeper stratified lakes of this type, poor in species and quantity in hypolimnion; Chironomus type; Corethra present.
   h. Deep-dwelling cold-water fishes usually absent; suitable for perch, pike, bass, and other warm-water fishes.
   i. Succession into pond, swamp, or marsh.

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*Welch, Paul S., 1952. Limnology. 2nd Edition. McGraw-Hill Corp., 538pp.

RECOMMENDATIONS

The Division Engineer recommends that a multiple-purpose dam and reservoir on the Big River, in Coventry and West Greenwich, Rhode Island, including flood control, water supply and recreation, essentially as described in this report, be authorized for construction by the Federal government with such modifications as the Chief of Engineers may consider advisable. The estimated total first cost of the recommended project is $71,219,000 for construction, exclusive of preauthorization costs, representing average annual costs of $6,484,000 including provisions for operation, maintenance and major replacements.

The President, in his June 1978 water policy message to Congress, proposed several changes in cost-sharing for water resources projects to allow States to participate more actively in project implementation decisions and to equalize cost-sharing between structural and non-structural flood damage reduction projects. These changes include a cash contribution from benefiting States of 5 percent of the first costs of construction assigned to non-vendible project purposes and 10 percent of the first costs of construction assigned to vendible project purposes. Application of this policy to the Big River Reservoir project would require the State of Rhode Island to contribute an estimated $6,786,000 in cash (5 percent of $6,277,000, the total estimated project first cost allocated to flood damage reduction, 5 percent of $451,000, the total estimated project first cost allocated to recreation and fish and wildlife enhancement, and 10 percent of $64,491,000, the total estimated project first cost allocated to water supply).

The President also proposed that cost-sharing requirements for flood damage reduction projects be modified to require a cash or in-kind contribution equal to 20 percent of the project first costs allocated to flood damage reduction. Application of this policy to the Big River Reservoir project would require that non-Federal interests, make, in addition to the State contribution, a cash or in-kind contribution of an estimated $1,255,000 (20 percent of $6,277,000, the total estimated project first cost allocated to flood damage reduction).

The Division Engineer recommends that construction authorization for the Big River Reservoir project be in accordance with the provisions of the President's cost-sharing policy. He further recommends that prior to initiation of construction of the Big River Reservoir and dam, non-Federal interests provide assurances to the Secretary of the Army that they will:

1. Provide without cost to the United States, all lands, easements and rights-of-way necessary for construction of the project.

2. Hold and save the United States free from damages, including damages from water rights claims, due to construction of the project, except damages due to the fault or negligence of the Unfted States or its contractors.

3. Maintain and operate all features after completion in accordance with regulations prescribed by the Secretary of the Army. Operation for flood control regulation would be as directed by the New England Division, Corps of Engineers, Waltham, Massachusetts. The cost of on-site operation and maintenance allocated to flood control, an amount currently estimated at $59,000, would be reimbursed by the United States.

4. Prior to construction of the water supply features of the recommended project, agree in accordance with the Water Supply Act of 1958 (PL 85-500, Section 301) as amended, to:

Reimburse to the United States that portion of the construction cost allocated to water supply, including interest during construction, an amount currently estimated at $64,491,000. Such reimbursement shall be repaid within the life of the project, but in no event to exceed 50 years after the project is first available for storage of water for water supply purposes, except that (1) no payment need be made with respect to facilities designed for future water supply until such supply is first used; and (2) no interest shall be charged on such cost until such supply is first used, but in no case shall the interest-free period exceed ten years. Limits on the cost which may be allocated to future water use and the interest rate used for purposes of computing interest during construction and interest on the unpaid balance shall be determined as specified in the Water Supply Act of 1958.

5. Construct, operate and maintain all other water supply features of the Recommended Plan which are an integral part of the Big River Reservoir project and not incorporated in the recommended project for Federal implementation. These include water and sludge treatment facilities, the finished water aqueduct to the Providence water supply system, and implementation of the water conservation program.

6. Protect channels and floodplain areas downstream of the project from encroachments which would adversely affect reservoir operation.

7. Exercise to the full extent of their legal capability, control to prohibit the removal of water from the watershed which would affect the reservoir's water supply storage and the development of dependable stream regulations.

8. In accordance with the provisions of the Federal Water Project Recreation Act (PL 89-72) as amended:

a. Administer project land and water areas for recreation and fish and wildlife enhancement.

b. Pay, contribute in-kind, or repay (which may be through user fees) with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $146,000.

c. Bear the costs of operation, maintenance and replacement facilities for recreation and fish and wildlife enhancement, an amount currently estimated at $20,000 on an average annual basis. The cost of operation and maintenance allocated to joint use recreation costs would be reimbursed by the United States.

C. E. EDGAR, III
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Commander and Division Engineer

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